REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2001	Final Technical, 2001

4. TITLE AND SUBTITLE
Report of the Defense Science Board Task Force on Training Superiority & Training Surprise

5. FUNDING NUMBERS
N/A

6. AUTHOR(S)
Dr. Joe Braddock and Dr. Ralph Chatham, Co-Chairmen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Defense Science Board
Office of the Under Secretary of Defense (AT&L)
3140 Defense Pentagon
Room 3D865
Washington DC 20301-3140

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Science Board
Office of the Under Secretary of Defense (AT&L)
3140 Defense Pentagon
Room 3D865
Washington DC 20301-3140

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
N/A

12a. DISTRIBUTION AVAILABILITY STATEMENT
Distribution Statement A: Unlimited Distribution

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*

14. SUBJECT TERMS	15. NUMBER OF PAGES
	44
	16. PRICE CODE
	N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	N/A	N/A

REPORT OF THE

DEFENSE SCIENCE BOARD
TASK FORCE

on

Training Superiority & Training Surprise

January 2001

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR
ACQUISITION, TECHNOLOGY & LOGISTICS
WASHINGTON, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense.

This report is UNCLASSIFIED

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY AND LOGISTICS)

SUBJECT: Final Report of the Defense Science Board Task Force on Training Superiority and Training Surprise

I am forwarding the final report of the Defense Science Board Task Force on Training Superiority and Training Surprise.

The Terms of Reference directed the Task Force to:

- Assess the current state of training within DoD;
- Identify the characteristics and advantages of possible future learning environments and what key enablers are required to achieve those learning environments;
- Assess the opportunities for and impediments to implementing alternative training strategies;
- Identify actions necessary to enable the development and implementation of advances in individual, collective, and unit training, by OSD and the Services.

The Task Force determined that a second training revolution is brewing and offers exciting possibilities as the US strives to reach JV 2010/20 goals. Achieving the second training revolution is affordable if DoD properly structures itself to recognize all the benefits of this training. Furthermore, the US must ensure that potential adversaries do not surprise the US by embracing the new technologies without our knowledge. Therefore, the intelligence community must be on the look out for signs of increased adversarial capability due strictly to training.

I endorse all of the Task Force's recommendations and recommend you forward the report to the Secretary of Defense.

Craig Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Training Superiority and Training Surprise.

Attached is the report of the Defense Science Board Task Force on Training Superiority and Training Surprise. The Terms of Reference directed that the Task Force:

- Identify key training demands that affect development and maintenance of military proficiency;
- Recommend how to create and maintain individual proficiency among our warriors and support personnel;
- Identify key military training infrastructure which may be needed, especially in the areas of advanced distributed learning, embedded training, global networks and information resources, netted training, and advanced simulations;
- Identify useful indicators of high-leverage training programs for use by the intelligence community to prevent training surprise.

The Task Force believes that the U.S. armed forces possess a training superiority which compliments their technological superiority. Although few other states engage in similar training environments, the US must be constantly vigilant to both protect its training superiority edge and to ensure it is not surprised. Other specific findings include:

- Some forms of training can deliver order of magnitude warfare proficiency gains in times as short as 2 weeks.
- The process is currently conducted in specialized Army, Navy and Air Force combat training centers (CTC) for some, but by no means all, service forces. However, the infrastructure of these centers is being neglected.
- 2010/20 warfare will require more training, not less.
- The Acquisition and testing process pay little attention to how a weapon system will be provided with trained operators and maintainers.
- Inadequate & poorly timed training will negate the technical superiority of our hardware.
- A new training revolution is possible. It can pay for itself if structural problems are solved.
- Adversaries could use a new training revolution against us, but so far have been restrained by cost and cultural impediments.

Based upon the above findings, the Task Force recommends the following:

- The services restore the combat training centers.
- Services and JFCOM recommend how to expand CTC training to new warfare areas.
- USD(AT&L) make training a co-equal part of acquisition and testing by insisting that each acquisition program have a defined training subsystem.
- Put USD(P&R) on the Defense Acquisition Board
- USD(P&R) develop Advanced Concept Technology Demonstration (ACTD)-like pilot programs for each service to 1) make residential training self-paced and 2) move as much training from schoolhouse to just-in-time, just-right training in the units.
- DARPA establish a training technology research effort
- Charge someone at ASD/DUSD level with review and oversight of training performance and measurement thereof.
- DEPSECDEF request the intelligence community deliver yearly training report card on potential adversaries.
- The services report to DEPSECDEF yearly on the state of force training, concentrating on readiness, performance and adequacy, not on process.

The Task Force would like to express its appreciation for the cooperation, advice, and help by the government advisors, support staff, and the many presenters from commercial firms and government and research organizations.

Joseph V. Braddock Ralph E Chatham

Dr. Joe Braddock
Task Force Co-Chairman

Dr. Ralph Chatham
Task Force Co-Chairman

Table of Contents

In late 1998 the Undersecretary of Defense (Personnel & Readiness), the Director, Defense Research and Engineering, and the Joint Chiefs of Staff requested the Defense Science Board to create a task force on training and education. Drs. Joe Braddock and Ralph Chatham were appointed co-chairmen. The task force met periodically throughout 1999 and early 2000. This document is the report of our deliberations.

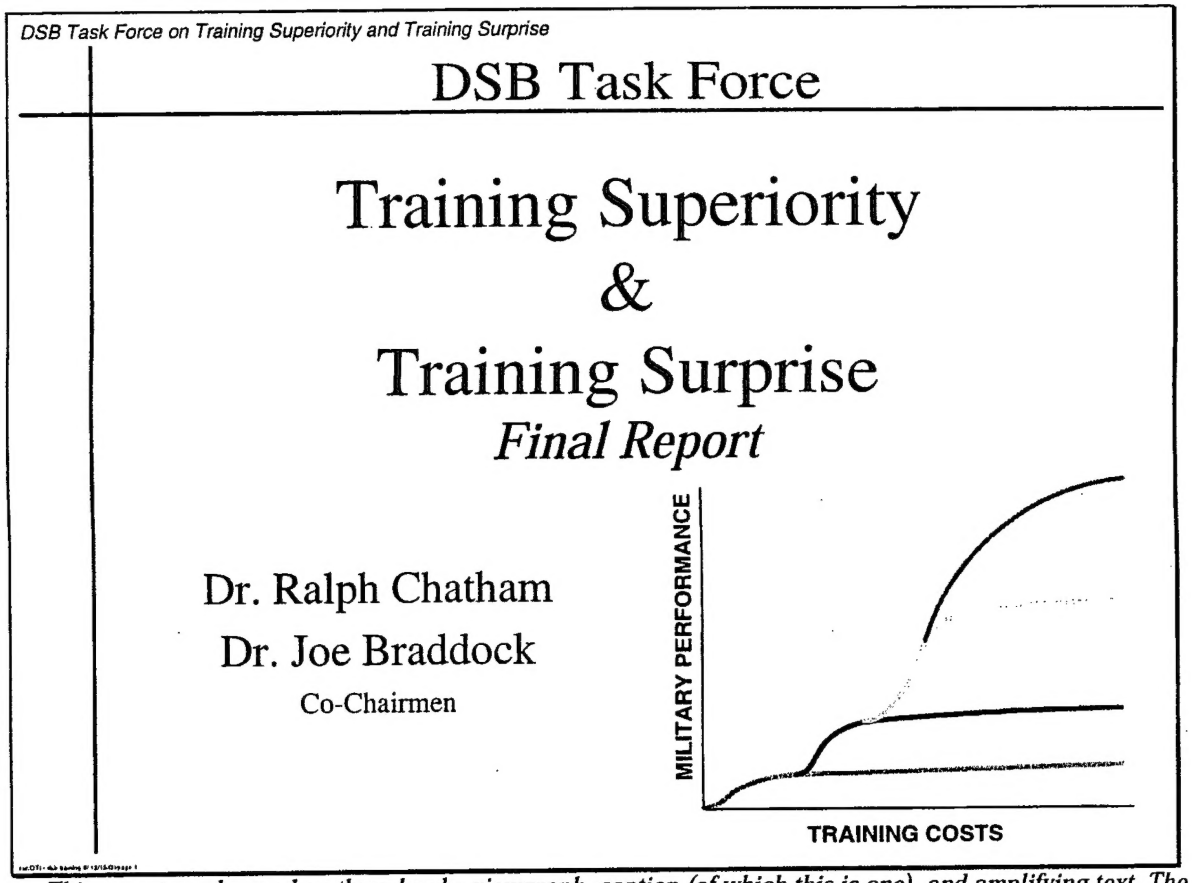
Much of what follows is more anecdotal and less quantitative than we would have preferred. Unlike the other Title 10 Service responsibilities (man and equip), training performance and resulting military proficiency are not well measured. Training is therefore easier to ignore. Thus, many of the training issues we raise are structural rather than technological; we found no one in the Pentagon with sufficient authority who is graded on force-wide training performance.

As we proceeded, our emphasis shifted away from education to highlight training superiority and training surprise. We were struck not only by the achievement of the Services where they apply engagement simulation in combat training centers (CTC) but by the failure of other nations to do this. This is, in part, due to a lack of resources.

This training revolution (CTC use) appears to be a uniquely American institution and not well coupled to more hierarchical cultures. It has had as profound an impact on warfare proficiency as advocates hope that the revolution in military affairs (RMA) will achieve in the future. Unfortunately, unless we give it more support than we have in the last few years, it may not be here tomorrow.

A second training revolution is brewing. Without it the RMA cannot be sustained. Thoroughly trained warriors are required to support concepts of massing fires, not forces, with widely spaced units flawlessly connected to each other and to their command structure. Future training must be delivered to the individual, to units, and to joint forces, when it is needed, not in the schoolhouse after which there is time for proficiency to decay. Training must be applied over and over again as the composition of the units and joint forces changes and as skills erode over time. Training must also become an integral part of the acquisition of hardware or we will fail to achieve the performance in our weapons systems that our other superiority (technology) strives to deliver.

Fortunately, technology is emerging that will support this and may save money in the process. Unfortunately, there is no



This report can be read on three levels: viewgraph, caption (of which this is one), and amplifying text. The sketch above suggests the relation between performance of complex tasks and a hierarchy of part-task learning curves that make for effective unit and individual training. See page 4 for more details.

training laboratory, development establishment, or manager with sufficient authority who can foster the second training revolution.

Training Surprise: In the last decade we surprised not only others but ourselves with our warfare proficiency. There is evidence that the culture of our first training revolution is itself trainable. A potential enemy might also be able to capitalize on the new training revolution. In 1994 Croatia surprised Serbia with a military proficiency built up in 1 year. Others could surprise us. Training superiority is ours to lose and for others to gain.

The panel was composed of people with relevant backgrounds in: military, defense acquisition, and training/ learning experts. Some members had participated in previous Defense Science Board (DSB) training studies. Several were recruited as well for an Army Science Board 2000 Summer Study Training Dominance Panel. In addition to those listed, observers and contributors from the Services, the Joint Staff, and the intelligence community attended out meetings.

We had eight meetings over approximately 1 year. The organizations listed on the chart spoke, as well as others. Most of our meetings were held in the Washington, D.C., area. A subgroup of us visited new air combat trainers at the Air Force Research Lab in Mesa, Arizona and at Langley Air Force Base. We visited the air CTCs, at Nellis Air Force Base, and Naval Air Station, Fallon, in Nevada.

Recognizing the importance of training for future forces, we chose to forgo a visit to an Army Combat Training Center and instead visited the Army's developing First Digitized Division, the 4th ID at Fort Hood - a critical part of the Army's transformation program. We held our final meetings at the newly named Joint Forces Command, in Norfolk, Virginia, and its Joint Training, Analysis, and Simulation Center (JTASC) in Suffolk, Virginia.

DSB Task Force on Training Superiority and Training Surprise

The People and the Places

◆Co-Chairmen

Dr. Joe Braddock
Dr. Ralph Chatham

◆Task force members & government advisors :

Dr. John Christie
Dr. Paul Chatelier
Dr. Dexter Fletcher
LTG Bill Hilsman, USA (ret)
Dr. Sung Lee
RADM Fred Lewis USN (ret)
Mr. Joe Markowitz
Dr. Warren Morrison
Dr. Harry O'Neil
MG George Steiner USAR(ret)
Dr. Gershon Weltman
VADM J.D. Williams, USN (ret)
RADM Jerome Smith, USN (ret)
CAPT Wayne Thornton, USN(ret)
Ms. Sandra Wetzel-Smith

◆Executive Secretary

Mike Parmentier
& Dan Gardner

Briefers, Contributing Organizations, Site Visits

ODUSD(R)R&T,PP
Joint Staff (J-7) (JV2010)
USMC Combat Development Command
Defense Intelligence Agency
Joint Staff (J-7) (JPME)
USA Training Doctrine Command
AF Directorate of C² (XOC)
Dep. Dir. Naval Training (N-7B)
USA Training Directorate (DAMO-TR)
Dep.Chief NAVPERS (P&TI)
USMC Dep COS, Manpower&Reserve Affairs
USAF Dep COS for Pers, Edu. & Training
Joint Staff (J-7) (DOCNET demo)
A Dep. Chief NAVPERS (pers. & tra. resource)
USAF Edu. & Tra, Command (AETC)
OUSD for Acquisition, Technology, & Logistics
ODUSD for Program Integration
ODUSD(R) Readiness and Training
General Motors
HMT-303, FREST (maintenance monitoring)
DUSD Readiness
Defense Acquisition University (DAU)
USN Aegis Training & Readiness Center
Navy CVX Program Mgr. (PMS 378)
DD 21 Program Office, Manning, HSI, & Training Manager (PMS 500)
Apache PMO, USA Aviation Training Cntr.
Dr. J. Bruer; James S. McDonnell Foundation
Nav. Air Warfare Ctr. Training Systems Div.
USAF Research Lab, Mesa, AZ.
Dr. D. Towne; Behavioral Tech. Labs, USC
Dr. R. Sternberg; Yale University
Dr. A. Lesgold; University of Pittsburgh
Dr. A. Graesser; University of Memphis
Dr. R. Wisher; USA Research Institute
LTG Hilsman: USA Battle Cmd Sys.
USA 3 Corps, DCOS - Ft. Hood, TX
Digital Force Coordination Cell Dir., Ft. Hood
Technical Director & CCTT Dir., Ft. Hood
CTS Technical Director - Ft. Hood
Director, NSC DIO - Ft. Hood
CDR Navy Strike & Air Warfare Center
NSAWC - (multiple staff briefers) NAS Fallon
414th Combat Training Squadron, Nellis AFB
Commander 57th Wing Nellis AFB
Commandant, USAF Fighter Weps. School
D. Commandant, USAF Ground Ops School
Joint Forces Command (JFCOM),
Joint Warfighting Center (JWFC),
Joint Training, Analysis, & Sim. Center (JTASC)
JFCOM (J-7)
ODUSD (S&T), Director, Biosystems
JWFC, Dir. For Interoperability
Nat'l Intel Officer Conventional Military Issues
DIA, CIA, and Service Intel centers
Director, OSD Readiness and Training
Space & Naval Warfare Center (IMAT brief)
Director, OSD (R&T) Adv. Dist. Learning
DoD Chancellor, Edu. & Prof. Development

This is a partial list of who we are and whom we talked to.

Summary of Findings
&
Recommendations

This chart summarizes our findings and recommendations. We will address each element in more detail later and then return to this chart at the end.

We found:

-The U.S. armed forces have a training superiority that complements their technological superiority.

-Some forms of training can deliver order of magnitude warfare proficiency gains in times as short as 2 weeks.

-The process is currently conducted in specialized Army, Navy, and Air Force combat training centers (CTC) for some, but by no means all, Service forces.

-The infrastructure of these centers is being neglected.

-2010/20 warfare will require more training, not less.

-Training is also neglected in acquisition and testing; little attention is paid to how a weapon system will be provided with trained operators and maintainers.

-Inadequate & poorly timed training will negate the technical superiority of our hardware.

-A new training revolution is possible. It can pay for itself if cultural and structural problems are solved.

-Adversaries could use this against us, but so far have been restrained by cost and cultural impediments.

We recommend that:

-The Services restore the combat training centers.

-Services and Joint Forces Command (JFCOM) recommend how to expand CTC training to new warfare areas.

-Undersecretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) make training a co-equal part of acquisition and testing by insisting that each acquisition program have a defined training subsystem.

-Put Under Secretary of Defense for Personnel and Readiness (USD(P&R)) on the Defense Acquisition Board (DAB).

-USD (P&R) develop Advanced Concept Technology Demonstration (ACTD)-like pilot programs for each Service to 1) make residential training self-paced, and 2) move as much training as possible from the schoolhouse to just-in-time, just-right training in the units.

-Defense Advanced Research Project Agency (DARPA) establish a training technology research effort.

-Charge someone at Assistant Secretary of Defense(ASD)/ Deputy Under Secretary of Defense(DUSD) level with review and oversight of training performance and measurement thereof.

DSB Task Force on Training Superiority and Training Surprise

Summary

- ◆Our uniquely American ***Training Superiority*** is eroding
- ◆JV2010/2020 future will require more training, not less
- ◆Training failure will negate hardware promise
- ◆A second revolution in training is needed and is possible
  - ➢ *This new revolution should be able to pay for itself but:*
    - ✧The incentive structure in the DoD won't foster the revolution without help
      - ♦ A central cause is that ***training performance is not measured***
- ◆Training should take its Title 10 seat with "Man & Equip"
  - ➢ *Restore & expand upon crown jewels of current training revolution (CTCs)*
  - ➢ *Establish and test co-equal training subsystem in each acquisition program*
  - ➢ *Raise OSD/Acquisition training conscience:*
    - ✧Services & CINCs deliver annual training report card to Deputy Secretary
    - ✧Designate ASD/DUSD to be held accountable for training performance
  - ➢ *Foster the second training revolution by establishing:*
    - ✧ACTD-like pilot programs in computerized self-paced and unit-based training
    - ✧An advanced training research program element
    - ✧DARPA office to develop high payoff training/human performance technology
- ◆DoD & Intel Community act to detect & avoid Training Surprise

Training performance (versus process) is seldom measured. Because no one with adequate authority is graded on (unmeasured) training performance in units, in joint forces, or in acquisition, training plays second fiddle to "Man and Equip." Consequences and recommended actions are shown above

-Deputy Secretary of Defense (DEPSECDEF) request that the intelligence community (IC) deliver a yearly training report card on potential adversaries.

And last, but perhaps most important, we recommend:

- The Services and Commander in Chiefs (CINCs) report (with Joint Staff endorsement) to the Deputy Secretary of Defense yearly on the state of force training, concentrating on readiness, performance, and adequacy, not on process. The Service reports are to be on service training; the CINC report card is to cover the state of joint training. The report's format is not important, but its routine delivery should produce the kind of training readiness accounting that is needed to prevent the Department of Defense (DoD) from overlooking tradeoffs between training and hardware.

Detailed Overview

The next three charts discuss some of the characteristics of learning and training.

The word training has many meanings and is often used as a synonym for education. For the purposes of this report, training differs from education in that training is geared to developing specific skills and delivering people who can perform defined tasks. Education is a more general process with a broader goal.

Military training can be sorted in a number of ways. One such sorting includes training to develop: Service/military culture, basic military skills, technical skills, specific weapon system operation skills, small unit warfighting skills, larger unit battle proficiency, combined arms and interoperability warfare skills, theater, joint and coalition warfare skills.

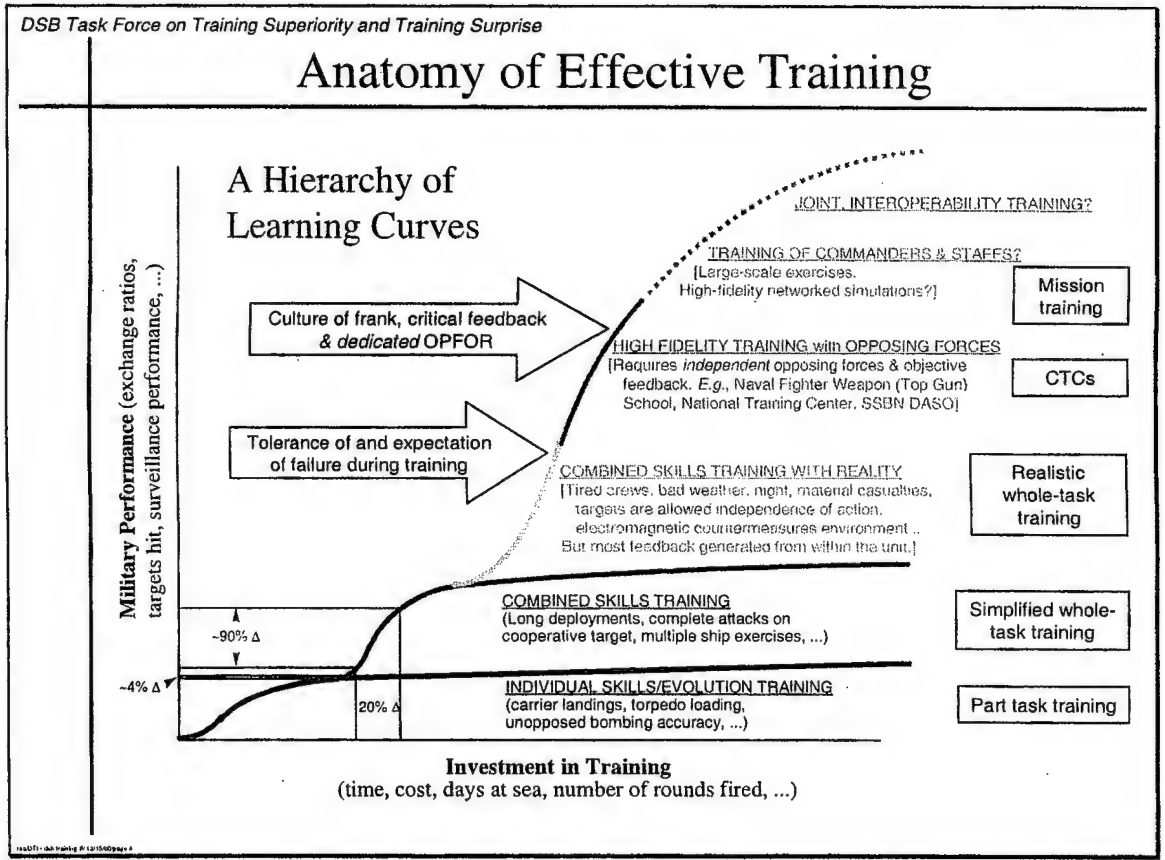
Another way of sorting the complex training picture is suggested in the chart. The process is often viewed with the aid of a learning curve: a plot of the skills achieved as a function of the investment in training. The slope is shallow at first. For example, in pilot training, flying proficiency remains minimal throughout ground school, climbs rapidly during the early flights, and then flattens out again.

When measured far out in the learning curve it often appears that training investments do little to improve performance. For example, in a large sample of qualified Navy pilots, a 20 percent change in average flight hours yielded only a 4 percent improvement in carrier landing skills. Looking at single task learning curves it is hard to see how CTC training can make such a dramatic improvement in already-trained pilots or Army units.

While considering this conundrum several years ago, one of us (Thornton) pointed out that warfare is a complex task and training for it involves a stacked set of learning curves, each springboarding off the levels below it. Carefully done, training can stay on the steep part of the learning curve until an entire joint or combined-arms force is trained for its warfare mission.

Currently the process stops cascading at the level of the CTCs. Higher levels of training are performed in a detached and uncoordinated process; it is currently very expensive to conduct mission-level training with the entire force. The new training revolution may make this kind of training affordable.

The stacked learning curves are by no means the whole story, however, for what is learned is often forgotten, as we will see in the next chart.



When proficiency in simple tasks is viewed as a function of training investment, the learning curve flattens out. Warfighting is not, however, a simple task. Viewing training for war as a set of layered learning curves helps to visualize why CTCs work. One lesson, for example, is that CTCs shouldn't work well if basic skills have not been first trained into the unit. Integration of mission training (the dotted line) into the lower levels is not yet achieved.

After training, if complex skills are not constantly exercised, proficiency will decay substantially in times as short as a few months. At that point some level of retained skill remains, and stays with the individual for years. For complex tasks such as flying, proficiency can be regained with refresher training in as little as a few weeks, even after several years of not exercising the skills. Over-training can slow the loss and improve the base level to which skills decay.

The graph shows one case of this process. The Navy patterned their Strike University (now combined with other air weapons courses at NAS Fallon) after the first CTC, Top Gun, to teach pilots air-to-ground combat skills. Pilots are well trained *before* they go to Strike University in order to be well prepared to gain the maximum value from CTC learning, and gain they do.

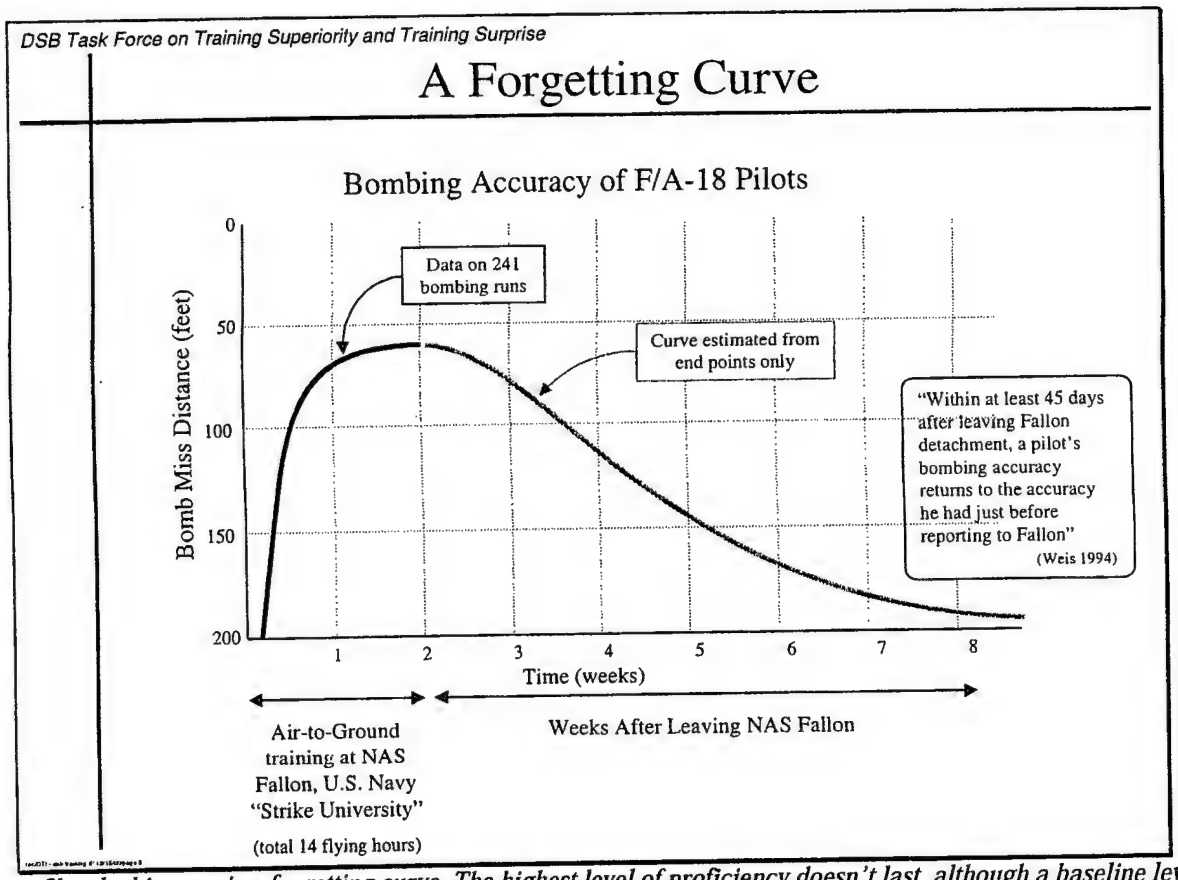
A 1990 Center for Naval Analyses review of 241 bombing runs concluded that after 14 flight hours of training, the average pilot's bombing error deceased by a factor of 3.3. The first factor of 2 improvement came in the first 4 hours. 45 days later, however, bombing accuracy had decayed to the initial level.

Note that it is not as easy to measure the forgetting curve as it is the learning curve. If you test an individual several times, the very act of testing provides refresher training. Given the steepness of the learning curve, one or two trials should deliver substantial performance improvements. The forgetting curve shown here is only a guess at what happens between the two endpoints.

Our current training and deployment schedules are ill matched to a skill decay time of 2 to 3 months. Unless tactical refresher training is provided within the deployed units in the field, the refresher training will occur in combat. We show later evidence that this unfortunate situation may be the case today.

The new training revolution may help here. We saw the Air Force's new Distributed Mission Training (DMT) System at the Air Force Human Resource Laboratory's (AFHRL) Warfighter Training Research Division. The DMT allows four pilots to fly together against a simulated adversary. Its fidelity is not exact, but it can deliver realistic training on 80 to 85 percent of complex air-to-air warfare tasks that a CTC can deliver. It also allows some freedom to train in ways that safety considerations do not permit in any real aircraft.

These kinds of training devices should be an integral part of equipment deployed with combat units, for example on aircraft carriers in forward areas. System fidelity should grow quickly in the future and their cost should drop, but care must be taken that they do not deliver negative training.

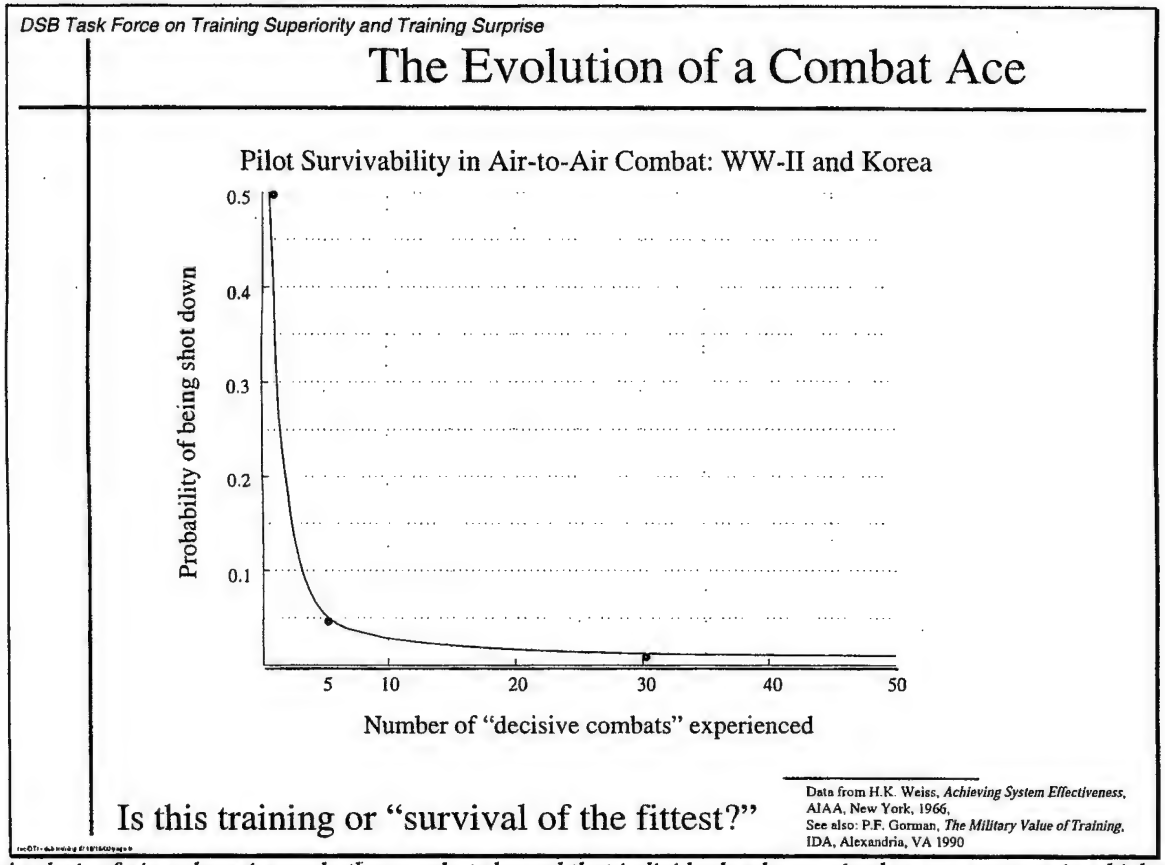


Sketched in gray is a forgetting curve. The highest level of proficiency doesn't last, although a baseline level remains. Peak performance can often be restored quickly by refresher training. Note that the time between most predeployment training and combat during that deployment exceeds the forgetting time.

We emphasize that the phenomenon of skill decay does not mean that advanced training in a CTC is useless. For example, we will show that time to reacquire warfare proficiency is greatly reduced for those who learned in a CTC. Consideration of skill decay times, does, however, suggest that training systems for complex tasks should be designed such that 1) the training occurs as close in time as possible to when the skills are needed, and 2) methods should be devised to deliver key features of the training to deploy with units.

Historical research by Weiss and others established the understanding that in air combat the more successful engagements a pilot had, the higher the probability that he would survive the next one. An "ace" (pilot with five kills) had a 95 percent probability of being the winner of his next decisive engagement (one in which somebody is shot down) as opposed to the novice, who had less than a 50 percent chance. The winner of 30 decisive engagements was almost invulnerable. Weiss also showed this general trend was the case for other combat situations, for example with submarine captains in World War II.

Weiss believed that this was a selection effect, that aces were born, not made. The best pilots survived and the worst got shot down. However, what the Navy's "Top Gun" school (and later the Air Force's Red Flag Exercises and the Army's National Training Center) showed was that this was more than survival of the fittest; it can be the result of learning. Moreover, it is possible to train to the ace level without bloodshed.



Analysis of air, submarine and other combat showed that individuals who survived an engagement in which a kill was achieved were much more likely to win the next one. Until Top Gun, this was thought to be battlefield Darwinism. We now know that much of the effect is the result of to training.

Most U.S. combat forces enjoy a substantial training superiority over potential adversaries. Much of this comes from the use of CTCs, an invention of the Navy tactical air forces over 30 years ago. This new approach to training delivered a dramatic change to their air-to-air combat proficiency over Viet Nam (discussed in the next chart). In the 1970s and early 80s the Air Force and Army adopted their own versions of the technique with the Army's CTCs created to train units as large as a brigade at one time.

In a CTC trainees gain the kind of experience that Weiss showed develops combat aces, but in a CTC there is no risk of dying from enemy fire. Trainees are far better prepared for combat than forces trained by other methods. In their Red Flag Exercises, for example, the Air Force's prime objective is to give the "blue four" (novice pilot in a four airship formation) a chance to get seven or eight combats under his/her belt so that he/she won't have to experience the dangerous part of the learning curve during real combat.

Until 1991 the Army's first battle of each war had been a disaster. In Desert Storm, after a decade of CTC use and with the insistence that every unit that went to war had to do well in the National Training Center, the Army had an overwhelmingly successful first battle. A second battle was not needed. There is little doubt that training was a prime contributor to that victory.

The key elements of the CTC process include: a highly competent independent opposing force that uses the tactics and equipment of the potential enemy; careful post-exercise reconstruction enabled by the use of an instrumented range; an after-action review, which consists of frank, objective feedback to the trainee of what was done and not done in each engagement; and an expectation of failure in the trained unit.

The last two features in particular appear to be uniquely coupled to American culture. We found no other armed forces that had been able to implement engagement simulation for their general forces. We found no training as effective as that performed in our CTCs except in a few foreign special force units.

The CTC process is used by most of the Army and the tactical air forces of the Navy and Air Force. Its institution for these forces amounted to a revolution in training. That revolution has not, however, expanded elsewhere within the Services, nor is it applied routinely for joint warfare training. Most of the Navy, for example, is not aware of the spectacular results that can be achieved by CTCs.

DSB Task Force on Training Superiority and Training Surprise

Our Second Superiority

- The superb performance of our military in the 1990s was not just a result of technological superiority but equally of TRAINING SUPERIORITY
- New combat training approach invented 30 years ago develops, without bloodshed, individuals & units into aces
  - ✧Instrumented ranges at major Combat Training Centers (CTCs)
  - ✧Highly competent Red/Opposing Force uses "enemy" equipment and tactics
  - ➢ *Uniquely coupled to American culture*
    - ✧Objective, no-holds-barred feedback/replay
      - ♦ no longer does first person to blackboard win
    - ✧Expectation of failure in the trained unit and its commanders
  - ➢ *Used by Army & most of the air forces (USAF, USN)*
- A second training revolution is brewing
  - ➢ *It will be needed for future warfare*
  - ➢ *But there are impediments to its implementation*

Since WW II we have claimed that we will win wars with technological superiority. Having found in Viet Nam that technology does not always bring victory, the Army and our air forces have developed a second superiority: in training. It was a key factor in our Desert Storm victory.

The Second Training Revolution:

There is an opportunity to create a second training revolution (the first being that started by the Navy Fighter Weapon, Top Gun, School). The new revolution will be fueled by advances in both learning theory and computer technology. We may soon be able to export to many other parts of the military and to joint operations the kind of training that engagement simulation currently brings to U.S. pilots and Army units. Unfortunately, like other revolutions, there are institutional forces that stand in the way. We will discuss these later in the report.

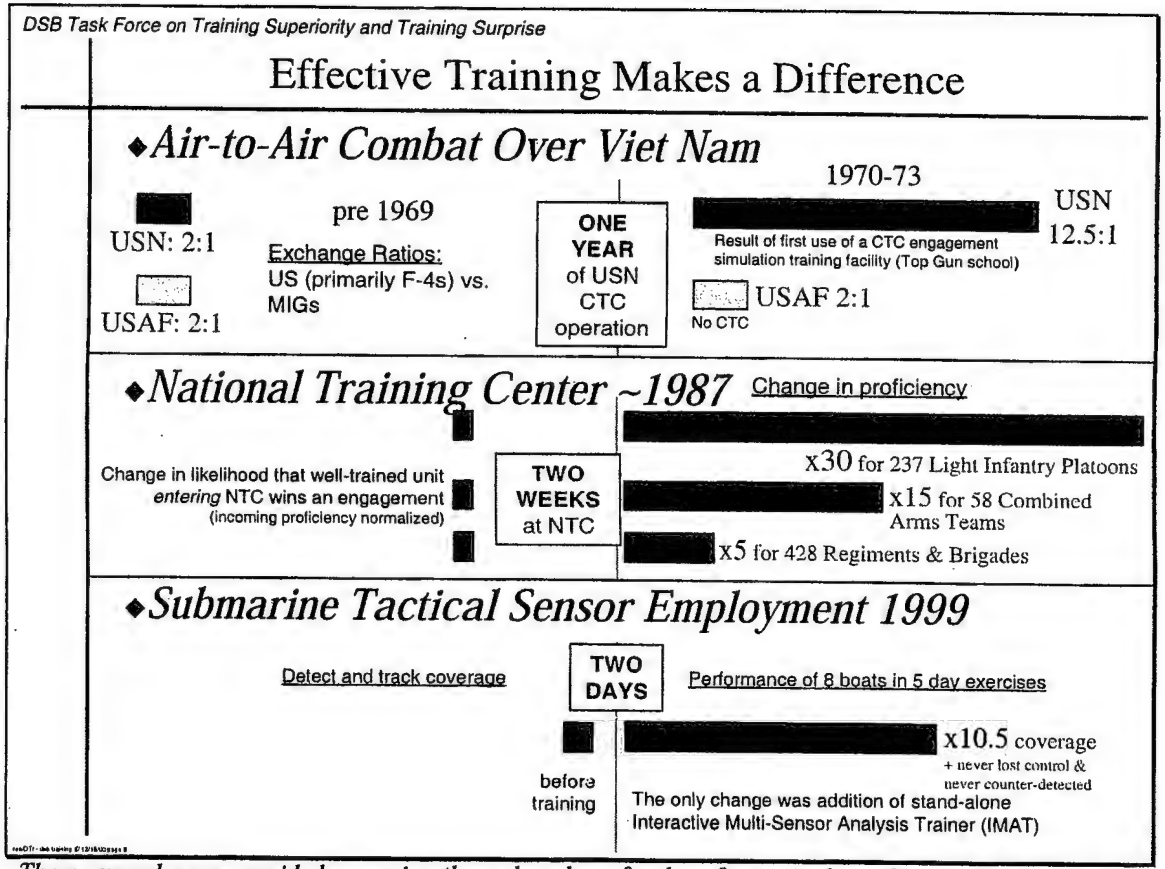
The air war over Viet Nam produced one of the best warfare experiments (albeit an unintentional one) ever conducted. In the last few months of 1968 the Navy lost 10 aircraft while shooting down only 9 MiGs and had fired over 50 air-to-air missiles without achieving a single kill. In 1969 no planes were shot down on either side because of a bombing halt. When the air war resumed, the Navy's kill ratio was 12.5 to one while the Air Force's fell slightly to 2.0 to one. These ratios are based on the order of 100 enemy aircraft shot down in the each of the three year periods (110 kills by U.S. pilots for 1965-1968 and 74 for 1970 to 1973).

Therefore, while there is some room to argue about details of aircraft types, weapons used, and personnel policy differences between the Navy and the Air Force, the sample size is large enough to yield a degree of confidence in drawing the conclusion that the change in kill ratios was real and that it was caused by the Navy delivering Top Gun trainees into the fleet.*

The results of the U.S. Army's tactical engagement simulations, as measured by changed performance at the training site, are as spectacular as the Top Gun influence on air war over Viet Nam. We would like to show examples from more CTCs but there *are* only a few more, totaling three for the Army and one each for the Navy and the Air Force. Moreover, data from the centers that do exist are sparse.

Other kinds of training can also produce spectacular results. We show an example of a single training device that changes the behavior of sonar operators so that they achieve an order-of-magnitude increase in submarine search area. The Interactive Multi-Sensor Analysis Trainer (IMAT) is a PC-based tool that allows a sonar operator and a submarine's tacticians to visualize a very complicated acoustic situation and determine how best to use their sensors. An investment of a few million dollars in this training research and development (R&D) project has demonstrated performance enhancements that far more expensive programs have not achieved.

Not so incidentally, the IMAT was developed by a training psychologist who also became a technical domain expert (S. Wetzel-Smith, a task force member). Many training systems are developed in the absence of one or the other of the two disciplines. That is one of the reasons that, although there are often more decibels (dB) per dollar in training than anywhere else, the training dB are not always realized.



Three examples are provided, spanning three decades, of order-of-magnitude performance enhancements brought about by a very brief period of training. These are successes. A subsequent chart shows some consequences of training failures.

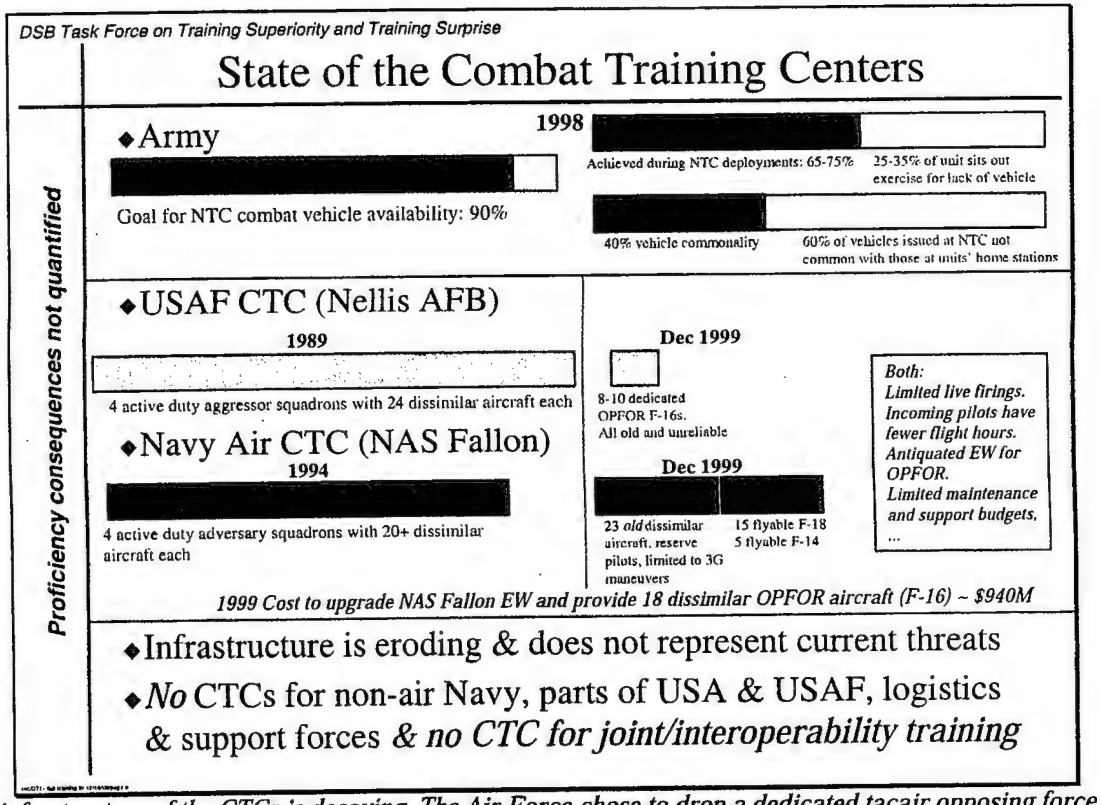
* Chatham, R.E., *Training Assessment: a Critical Intelligence Deficiency. A Report on the Intelligence Implications of Relationships Among Training, Exercises & Military Proficiency,* Dynamics Technology Report DTW-9509.02.9-96001, 1996, p. 18-24. Cited therein are: Gorman, P.F., *The Military Value of Training,* Institute for Defense Analysis Paper P-2515, December 1990 p 4, 5. "You Fight Like You Train," *Armed Forces Journal International,* May 1974 p 25, 26, 34.

The existing CTCs are not being supported as well as they were 5 or 10 years ago. The chart shows a few, easily measured examples; there are more. CTCs are the crown jewels of the first training revolution and a central foundation of our training superiority. Although the task force could not quantify the proficiency consequences of the decay in CTCs infrastructure, we are concerned that, at least for air-to-air combat, we may be at the edge of losing a substantial portion of the training value that these centers have offered in the past. Moreover, even if restored, the old infrastructure would not represent the current threats. Defining the new threats will not be easy.

The examples here are not parallel: the Army's does not describe the same kind of deficiency as those for the air CTCs. This partly reflects our choice to visit the Army's developing Digital Division at Fort Hood instead of one of their three CTCs. That decision was driven by our concern for how future systems and warfare concepts will influence training requirements. It is clear, for example, that the capabilities being developed in the Digital Division (4th Infantry) cannot be exercised properly in the current CTCs. Nevertheless, the Army's commitment to the CTC revolution appears stronger than that of the Navy and USAF air forces.

For example, the Air Force decided several years ago to forgo a substantial dedicated air opposing force (aggressor squadrons). "Red" aircraft in Air Force Red Flag Exercises are now manned mostly by active duty pilots who, with their aircraft, are borrowed from other squadrons. These pilots receive *negative* training for the time spent trying to imitate enemy tactics. Moreover, the aircraft used are not "dissimilar" (that is, they have the same characteristics as the trainee's aircraft). This seriously degrades the training experience.

The Navy still supports aggressor squadrons. The pilots are mostly reserves who must formally qualify as opposing force pilots within a week of flying. The aircraft used, however, are no longer all dissimilar and most are reaching the end of their useful lives. The (unfunded) cost to buy 18 F-16s as operational force (OPFOR) for USN was $638 million in 1999. We saw other indications of eroding infrastructure: many air crews get no live ordnance experience and the time between CTC visits is lengthening. It might be argued that the major warfare threat we experienced in the 1990s came not from aircraft but integrated air defenses (IADS), mostly ground-based, but air CTCs are losing these, too. An (unfunded) Electronic Warfare (EW) upgrade at



The infrastructure of the CTCs is decaying. The Air Force chose to drop a dedicated tacair opposing force; the Navy's cannot be sustained much longer. The Army is applying some resources to maintain their CTCs but not to upgrade them to support modern weapons/warfare.

NAS Fallon would cost $300 million over 10 years and leave the facility with a 10-year-old threat.

We emphasize that those manning the CTCs are superb warriors and operators. They do the very best they can with the resources provided, but that "can do" attitude may make it harder for them to call attention to the possibility that, even with their heroic efforts, the infrastructure has eroded to the extent that it may no longer support the kind of training we expect.

The foregoing only addresses issues with the current CTCs. We note, again, that a large portion of our forces do not use CTC training. A key element missing from even the most demanding training programs elsewhere in the Services is the notion of a *dedicated* opposing force that provides realistic simulation of enemy action.

We started out hoping to "bottle" CTC training and export it throughout the DoD. Given the erosion that we saw in the existing CTCs, we recommend first that they be restored and upgraded to meet the new threats and then funded to remain current.

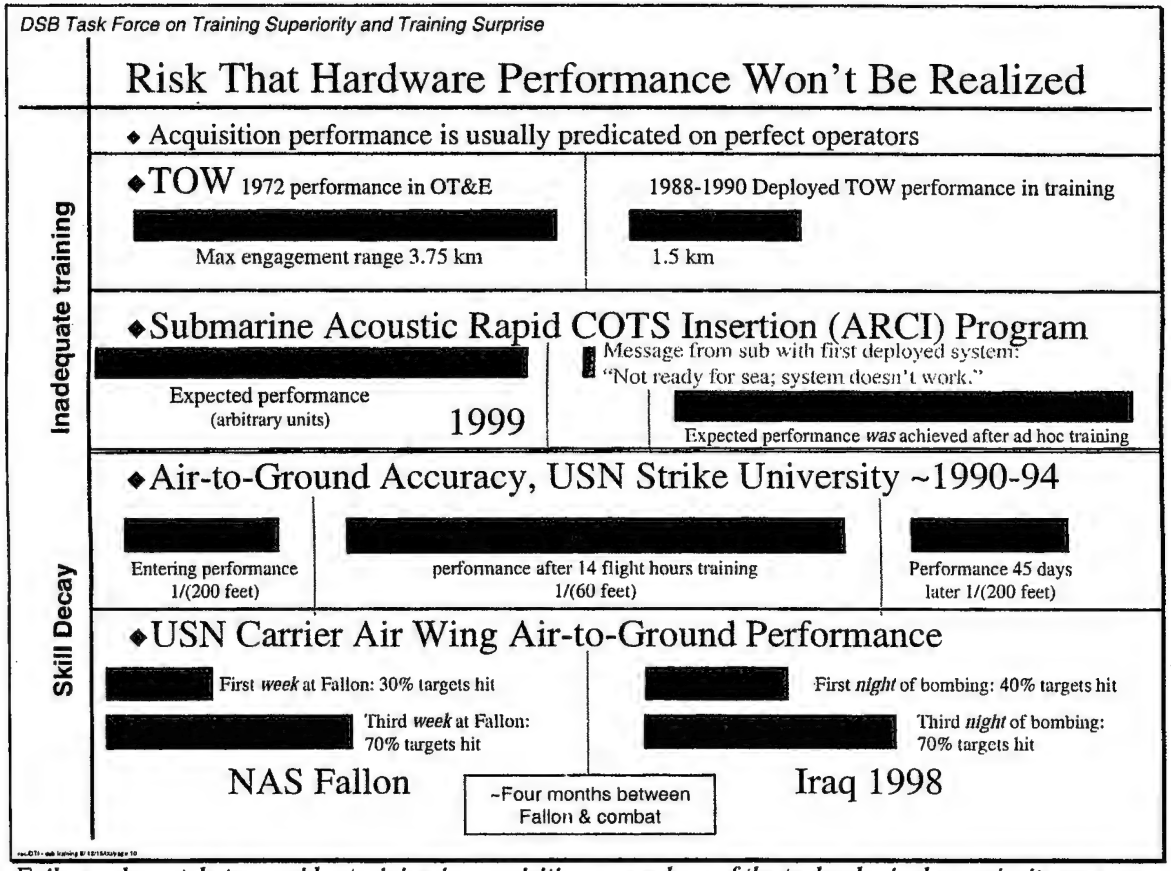
Historical examples suggest that there is a substantial risk that we won't achieve the performance that our technological superiority promises. The top two examples in this chart show cases where lack of appropriate or adequate training reduced substantially or completely negated the gains from a weapon development. The bottom two examples point out that even the best training if not applied at the right time can rob us of performance early in a conflict; as John Byron pointed out recently about Russian submariners, "people rust faster than ships."

The anti-tank weapon TOW was designed to engage targets at up to 4km range and showed that capability in operational test and evaluation. A decade later the Army found that it was only used at less than half that range. The conclusion of their investigation was that this was caused by a failure to train for over-the-horizon use. Had we known that only 2km of the missile's range would be used, we could have saved a large fraction of the development, production, and logistic cost of the weapon and designed it to fly only 2km.

The submarine force realized in the mid-1990s that the price of living with legacy computing hardware in their acoustic systems had become intolerable. They started a highly innovative program to replace all acoustic processors with commercial off-the-shelf computers for all attack submarines in a period of 4 years. The first boat to receive the upgrade was said to have more computing power than the sum of that available to all previous and existing submarines in the fleet.

The first message from that boat, however, stated that the new computers didn't work. The few days of training at the factory that the developers had thought would suffice were entirely inadequate to deliver lasting proficiency either to operate the hardware or to maintain it. (We will mention a parallel occurrence in the Army later.) Ad hoc remedial training fixed the submarine's problem, but the Navy will be hard pressed to deliver sufficient training as the pace of installations speeds up.

A major lesson learned by those charged with the remedial acoustic training program is that you can't know there is a training problem until you have ways to measure proficiency. They developed a proficiency test disguised as a sonarman "survey." Armed with knowledge of the test results they told me (Chatham) that the cheapest 10dB came from training, but they were still worried about the skill decay time.



Failure adequately to consider training in acquisition can rob us of the technological superiority we pay so much for. Even where training is well delivered, if it is not timely, skill decay will limit performance.

That brings us to the lower half of the chart. We have already seen similar Strike University data in the chart describing forgetting curves. Data on recent attacks against Iraqi targets suggest that deployed Navy forces suffered a similar decay, although the data are not as uncontaminated as for the Viet Nam Top Gun example. After a few missions the attacking force's performance returned to the level of bombing skill that units achieve in pre-deployment training at NAS Fallon over a period of 3 weeks.

Those at Fallon are trying to reduce the time between training and deployment, but more is needed; high fidelity onboard multi-aircraft training devices should be deployed with the units. The Air Force's new Distributed Mission Trainers (DMT), which allow interactive simulation training with four blue aircraft at a time are a start, but DMT is neither deployable nor embraced by the Navy.

The current acquisition system treats training as one of a number of "ilities" that must be considered during the acquisition process. Given its standing as one of nine (development, manufacturing, test and evaluation, verification, deployment, operations, support, training, and disposal), training is usually viewed as more of a nuisance or a block to be mechanically checked off than as a way to enhance performance by an order of magnitude (or conversely something that, if ignored, can reduce performance by a similar large amount). In one briefing we found training mixed on equal standing with crew privacy and food service.

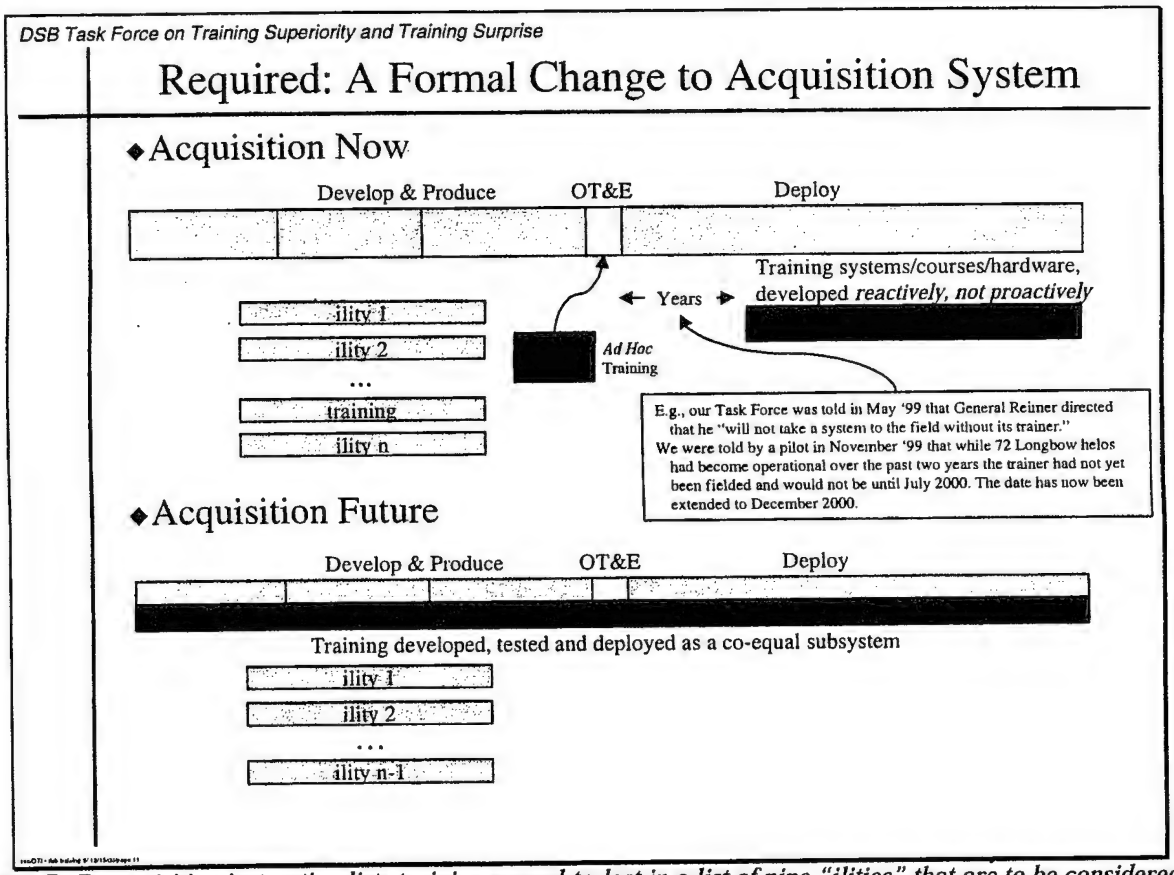
Training should stand as one of only three (man, equip, and train), rather than mixed up in the minds of acquisition managers with things like crew privacy. Failure to so view training leads to the kinds of performance failures discussed previously with the TOW missile and the submarine ARCI program.

We were reminded by task force member Bill Hilsman of a parallel to the Acoustic Rapid COTS Insertion (ARCI) case that occurred during the deployment of the Improved Hawk AAW missile in the late 1970s. Six months after it was deployed to the Middle East the I-Hawk batteries were 90 percent not operationally ready. Again the cause was a lack of training for the operators and the maintainers.

The Army changed its acquisition policies to insist that for each development program a training subsystem be formally designated and funded by acquisition dollars. If the training subsystem was not ready, the whole weapon system would be declared not operationally ready and would not be deployed. That policy did not last. We recommend it be instituted again, this time DoD-wide.

Consideration should be given at the beginning of a program to how competent operators will be provided throughout the life of the system. Some of the issues that need to be addressed include:

- Can ordinary operators deal with the system?
- Will the operators' professional advancement be dependent upon their proficiency with the new system, or will that not be tested?
- Will training devices and training courses be available at initial operational capability (IOC)?
- How can we test the adequacy of the training subsystem during the operational test and evaluation process?



The DoD acquisition instruction lists training second-to-last in a list of nine "ilities" that are to be considered. It stands only before "disposal". Given the major impact training can have on performance and the "man, equip and train" dictate of Title 10, training needs a new place in acquisition.

We heard a consistent lament during our deliberations: the biggest change in the military of the 1990s was that each Service, each unit, and each Service member is being asked to do more for less. The funding squeeze seems to be on everywhere, and training, as a thing that is hard to measure, is one of the first areas to be squeezed. Even if future warfare were not to change, a lower cost approach to individual skills training, as well as unit warfare training, will have to be found if we are to maintain our training superiority.

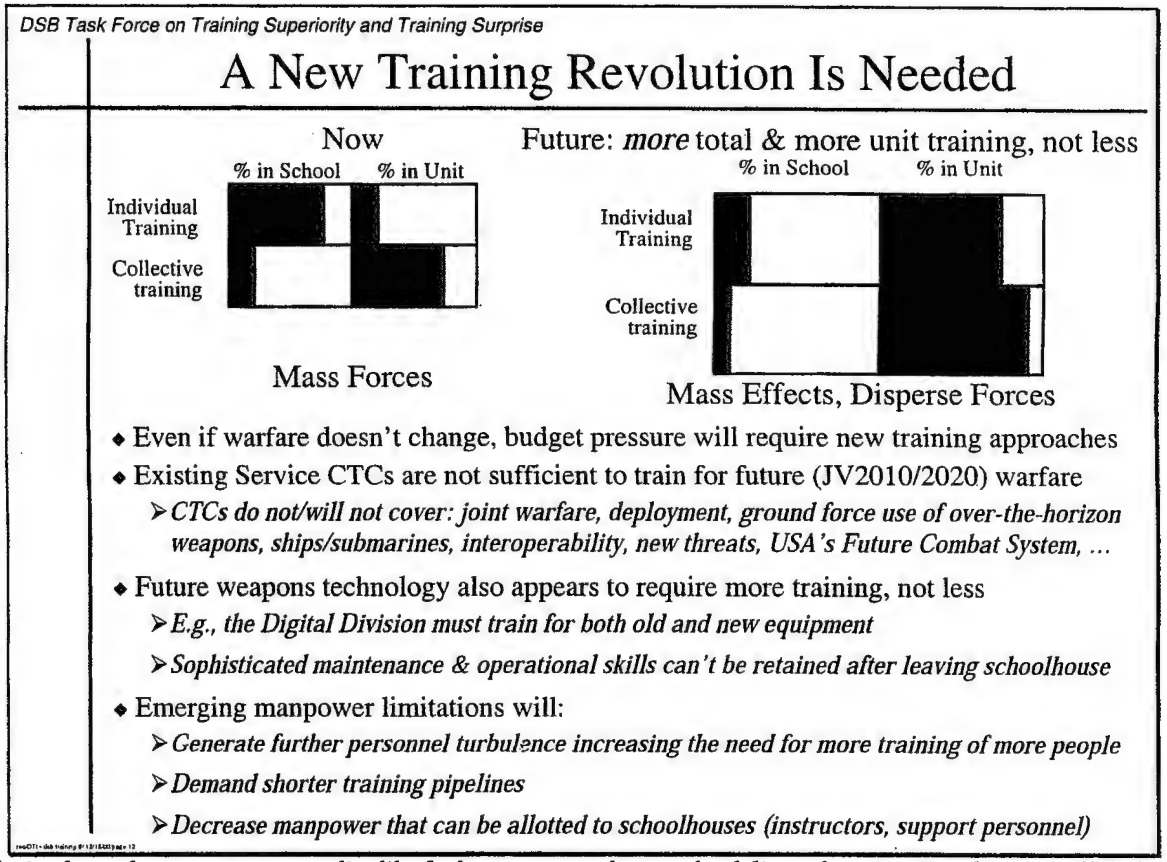
Warfare in the future will *not* be the same as it was in the past, yet the task force saw no plans anywhere, Service-based or joint, for fundamentally altering the training infrastructure to accommodate Joint Vision 2010/2020 warfare. As we found in the acquisition process, it appears that training is ignored when planning for the future in the tacit hope that it will solve itself. Training programs are, by and large, reactive, not proactive.

The characteristics of advanced weapons technology will also require changes in the current training architecture. A commercial anecdote illustrates this. General Motors found several years ago that they were spending over $3 billion per year on warrantee repairs. One third of the repairs were failures. They, therefore, instituted a comprehensive schoolhouse training program. After 4 years, half of their mechanics had received the schooling but GM then found that there was no difference between the repair performance of those with training and those without.

The cause, GM believes, is that their systems are both so reliable and so complicated that, after making a repair, several months elapse before a mechanic sees a similar problem again. This is too long a time to expect her or him to retain the specialized knowledge. We assert that this is true of military weapons maintenance and operations. It is a prime reason training must be moved from the schoolhouse to the unit.

GM, capitalizing on technology started, but not initially implemented by the DoD, began developing and testing the use of an integrated electronic tech-manual that delivered trouble shooting knowledge at the point of use for Cadillac transmissions. We were pleased to see a few instances of these devices being tried in the Services.

The next few charts discuss what we call a second training revolution: the application of computer technology and training research primarily to individual training. The promise of this revolution is that it will control the decay of skills by delivering training at the point of need and will enable complex training to be developed and applied inexpensively.



Trained people are not a commodity like fuel or weapons that can be delivered to a unit ready to use. Skill decay is a serious detractor from operational and maintenance proficiency in complicated systems. Training must move into the units where the right skills can be delivered at the right time.

Each of us has been educated and trained for a significant fraction of our lives. In consequence, we all have an intuitive understanding of how the learning process works. In many cases we are wrong. The academic learning community, as well, has its share of those who try to shoehorn all evidence into favorite theories about how they would like people to be, rather than find out what works. There is, however, a well-supported body of knowledge about how people learn.

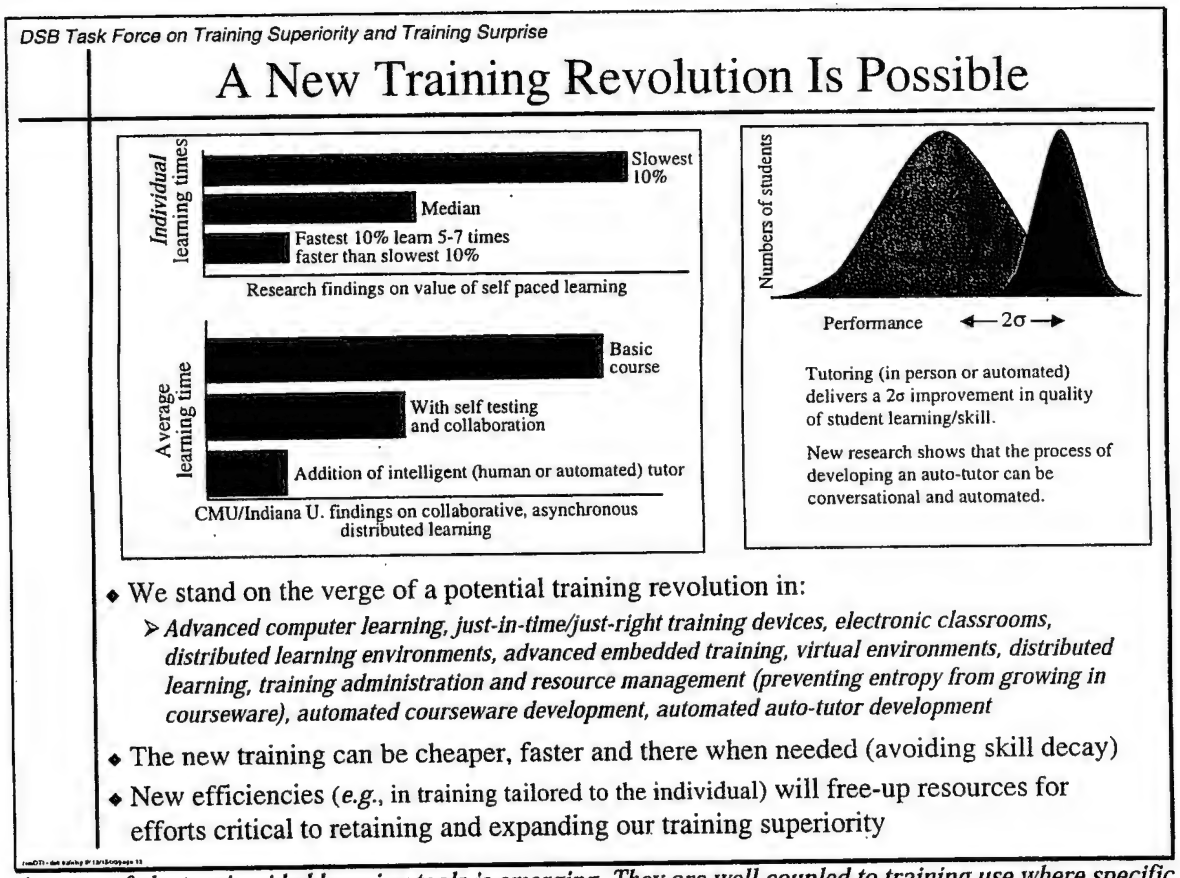
It is not surprising that CTC training uses many of the approaches now shown quantitatively to be more effective than conventional schoolhouse training: direct feedback, collaborative learning, and what amounts to individual tutoring. CTCs also benefit from the cognitive dissonance that comes from driving people very hard. Success in this kind of environment, like success in a demanding boot camp, can be shown to deliver persistent attitude changes toward belief in oneself, the organization, and the process.

We cannot rely on commercial training courses to give us help. Consumer training packages can't afford to use learning theory; their prime goal is to keep the cost of the product on the shelf below $29.95. Moreover, much of the emphasis in universities is on education. Our emphasis must be delivering people with a specific set of skills when and where they are needed and to do that rapidly and inexpensively without regard to campuses and tenure.

The graphs illustrate some characteristics (rate and quality) of group and individual learning. Trained people cannot be ordered in identical packages like weapons. We have already pointed out that skills, unused, decay more rapidly than steel rusts. A second difference between people and military hardware is variability. Learning time can differ by as much as a factor of 7 between the slowest learners and the fastest.

Residential instruction must bias its course length toward the slower student in a "one size fits all" approach. If the pace of a course can be matched to the learning rate of each student, average learning times can easily be reduced by 30 percent; in some cases the reduction has been as much as 80 percent.

Tutoring (individualized instruction with feedback using all the pathways of human-to-human interaction) does more than reduce the time to learn. It greatly increases the level of knowledge or skill in the student. The chart in the upper right points out that a tutor, even one lacking effective learning



A range of electronic-aided learning tools is emerging. They are well coupled to training use where specific course content and goals are easier to define than in education. Moreover, new techniques to automate courseware development hold great promise to reduce cost and improve quality.

techniques, can improve student skills by two standard deviations over what classroom training can deliver. In the next viewgraph we will show that the same benefits appear to be deliverable by an autonomous electronic tutor.

We have discussed a few examples of results from the limited research conducted on human learning. The slide lists other approaches that may deliver additional gains. Many of these, however, are being developed by technologists rather than those who understand learning processes. Research in computing and networking is well funded. Funding for research into how to use this to deliver skilled people when and where needed is measured in fractions of a percent of either the training or military R&D budgets. More training research should pay enormous dividends.

The University of Memphis had a problem. It required that all students take a computer literacy course but they were running out of instructors. Dr. A. Graesser, working under a National Science Foundation (NSF) grant, chose this domain area for the development of "Auto-Tutor."

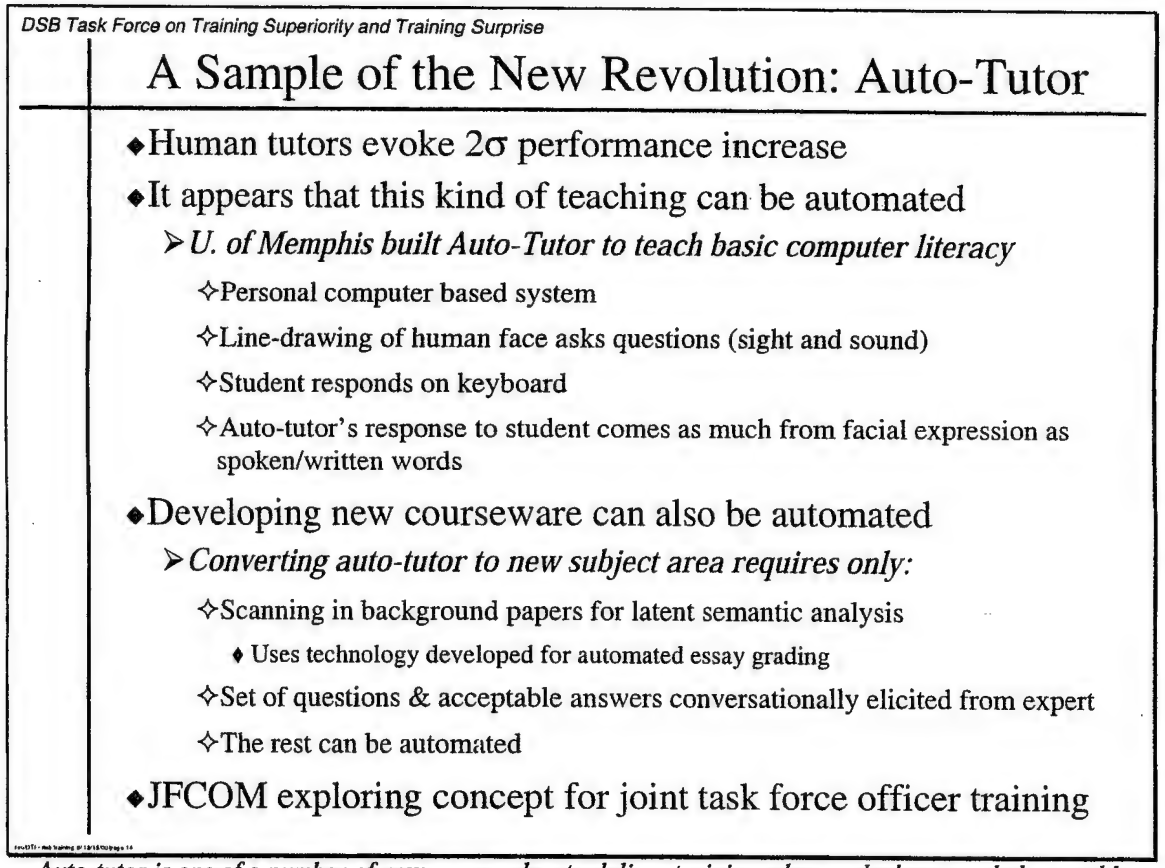
A student uses an ordinary personal computer to type in responses to questions asked aloud by the program. (Keyboard input was chosen because speech-to-text programs still have a 10 percent error rate and the time and distraction needed to correct mistakes is unacceptable.) The tutor is also represented on the monitor by both text and an animated line drawing of a human face (see the next chart). As a student types in her response she receives instant feedback from changes in facial expression in the animation. The student also gets an audible and textual response.

The Auto-Tutor guides the student through a series of open-ended questions that, if answered correctly, demonstrate the desired level of computer skills. It measures overall performance as well as how the student is answering the specific question. It automatically determines whether the student needs additional work in an area and chooses other questions to exercise him or her until that area is understood.

Auto-Tutor and its cousins, the electronic technical manuals, will only be affordable if new content on new subject matter can be acquired and inserted into the framework cheaply. It appears that this can be done. The developers of Auto-Tutor have created a conversational and automated method to create a tutor on a new subject by asking a domain expert to type in a set of questions that she believes will cover the skill area of interest. The development system elicits from the expert a set of seven or eight acceptable answers to each question. It also elicits potential incorrect answers.

In addition, review articles and other text on the subject area are scanned and subjected to a process called latent semantic analysis. It has been shown that automated sorting of the connections among words in text can lead to a computer-based essay grading system that evaluates student essays in the standard A through F system with a performance indistinguishable from that of human graders. Auto-Tutor uses the same technology to help it evaluate student responses to its questions.

Similarly, automated technical manuals can be generated by scanning existing printed manuals. The connections among the words and the structure are automatically analyzed and then reformatted in a structure suited for troubleshooting. (One wishes



Auto-tutor is one of a number of new approaches to deliver training when and where needed; portable integrated electronic technical manuals (IETMs) are another. What is revolutionary is that the courseware development can be automated, no longer requiring teams of cognitive scientists and domain experts.

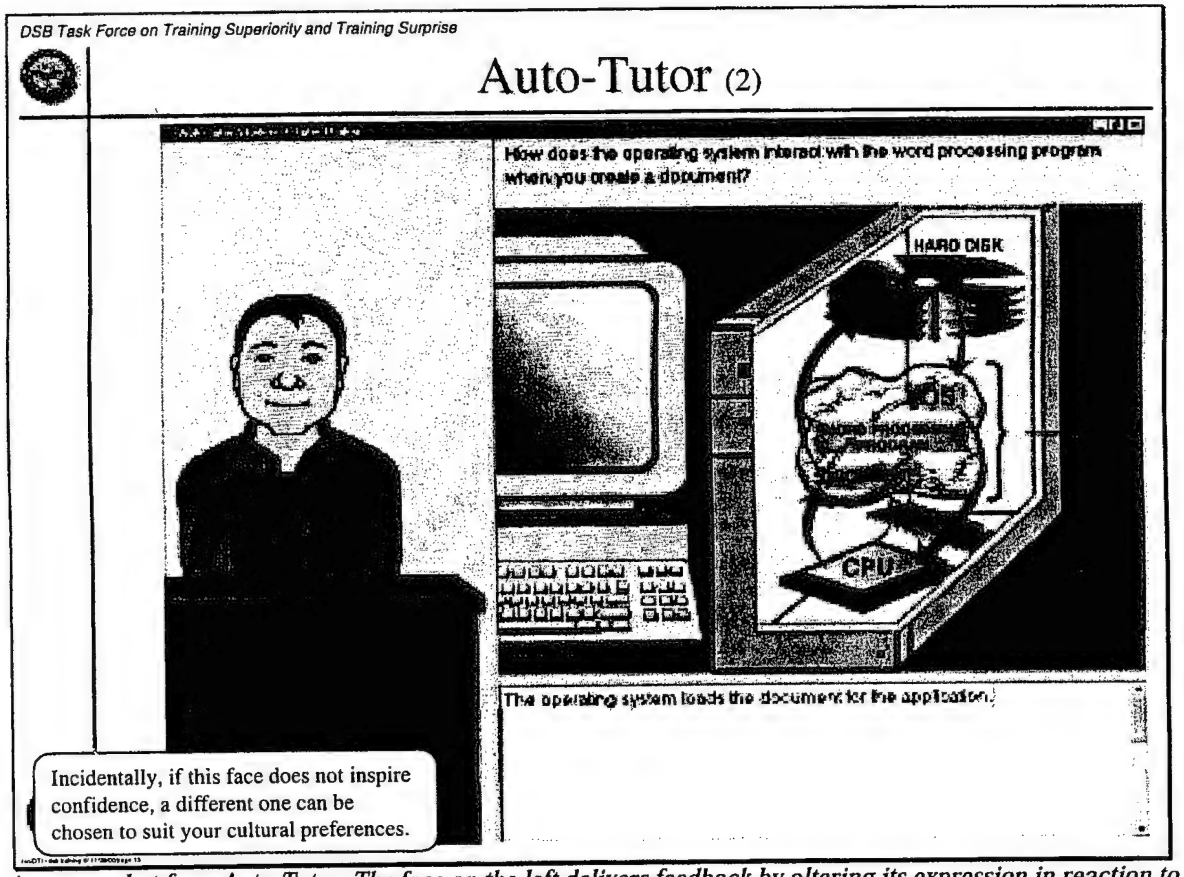
to avoid a web-based structure, which is not well suited to troubleshooting.) This process is claimed to be doable in 3 weeks.

Another month of work can animate the diagrams in the manual as well.

The military training value in these kinds of systems comes from:

1) Rapid, cheap, automated generation of training content/courseware.
2) Delivery of that content where and when needed.
3) Training delivery systems that use the learning pathways wired into humans rather than depending on reading text or looking at pictures on a computer monitor.

The words about Auto-tutor are on the last page. Perhaps the picture here will be worth a proverbial thousand additional words.



A screen shot from Auto-Tutor. The face on the left delivers feedback by altering its expression in reaction to the student's responses. The tutor's words are spoken and displayed on the screen as well. In the future we can expect that the student will be able to speak his or her answers instead of using the keyboard.

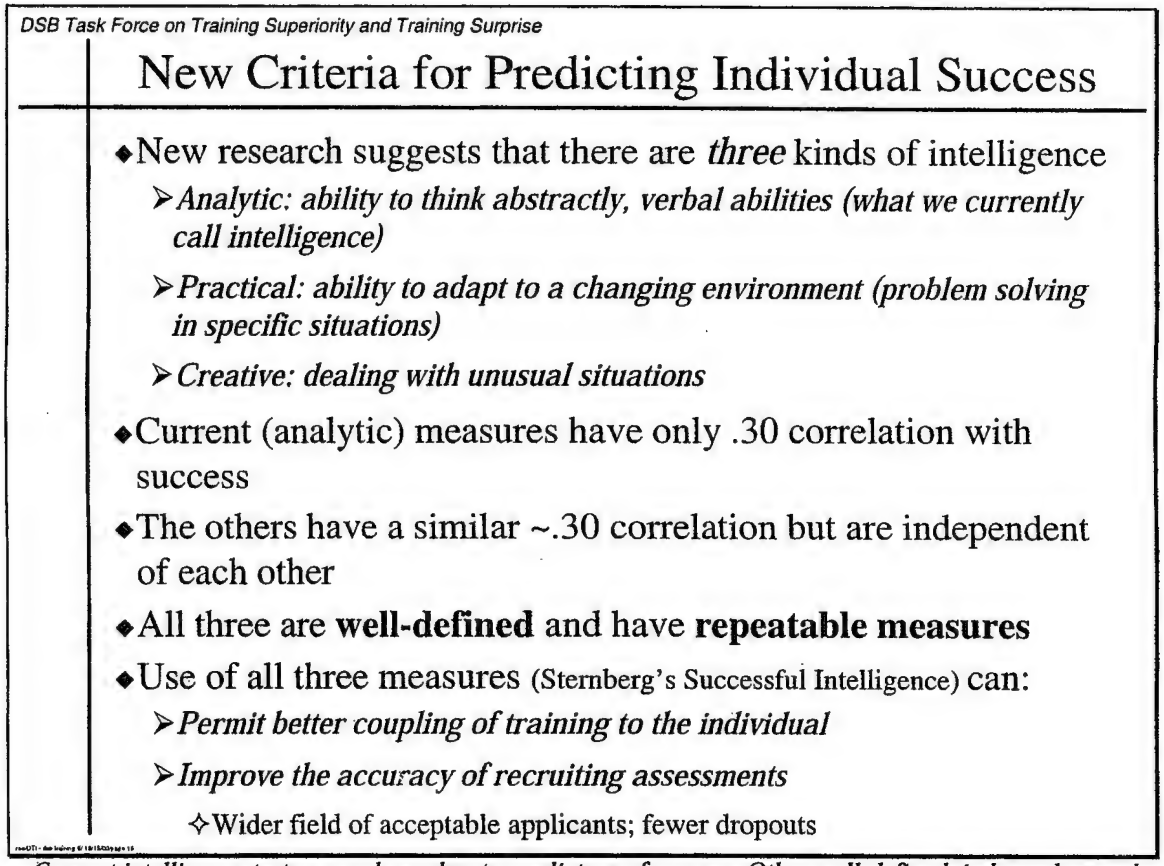
Self-paced learning and tutoring are facets of a more general concept of matching the instruction to the individual. Defining the individual in order to determine how best to train him or her leads to the issues of testing. The task force was struck by the concepts developed by Dr. R. Sternberg at Yale University.

He pointed out that what is measured by existing intelligence tests is an incomplete predictor of future success. For example, scores on the Graduate Record Examination (GRE) were known to predict only about 10 percent of the success in the first year of graduate school. Sternberg asked: How do the scores predict performance in the second year? The answer was that they were not correlated at all. Because the GRE measures abilities similar to those measured by our military entrance exams, this was disturbing.

Sternberg explored whether there are other measures that can partially predict future performance. He settled on two new characteristics that he calls "creative intelligence" and "practical intelligence." He has developed repeatable and well-defined measures of these traits. These measures individually have about the same predictive power as the currently used single measure (which he calls "analytic intelligence.") The use of these three, independent predictors of success should give us a better way to select applicants for entry into the military and help define the optimum ways to tailor training to the individual.

We believe that Sternberg's three intelligences are well established and that there is merit in his contention that the current strong dependence upon analytic intelligence as a societal selection criteria is unjustified and may be wasteful of human resources. The academic objectors to his combining the three into a "successful intelligence" fall primarily into three camps. One camp believes that any kind of characterizing of individuals is morally wrong, one thinks there is only one kind, and another declares that there are more than three kinds. Given this range of views, we believe that three is just about right. The payoff in training and retention for utilizing these new measures is high enough to justify a pilot program to determine if the Services can make better choices in recruiting.

Practical Intelligence measures the application of knowledge. It is tested for by asking questions about how to solve problems. In specific situations, it probes the ability to understand consequences of actions beyond what the conventional (analytic) intelligence measures. (i.e., conventional intelligence tests the ability to read, comprehend, and then compare and contrast.)



Current intelligence tests are only moderate predictors of success. Other well-defined, independent and repeatable measures of different kinds of "intelligence" have emerged. They independently predict success to a similar degree. Use of multiple measures should improve both training and retention.

Practical Intelligence might be tested for by describing a conflict situation and asking which of a set of possible courses of action would best resolve it.

Creative intelligence measures the flexibility of an individual to explore unusual situations. Imagine, for example, that there is a color called "grue" that is green before the year 2000 and blue afterwards. Creative intelligence testing will ask what inferences one can draw from this counterfactual situation.

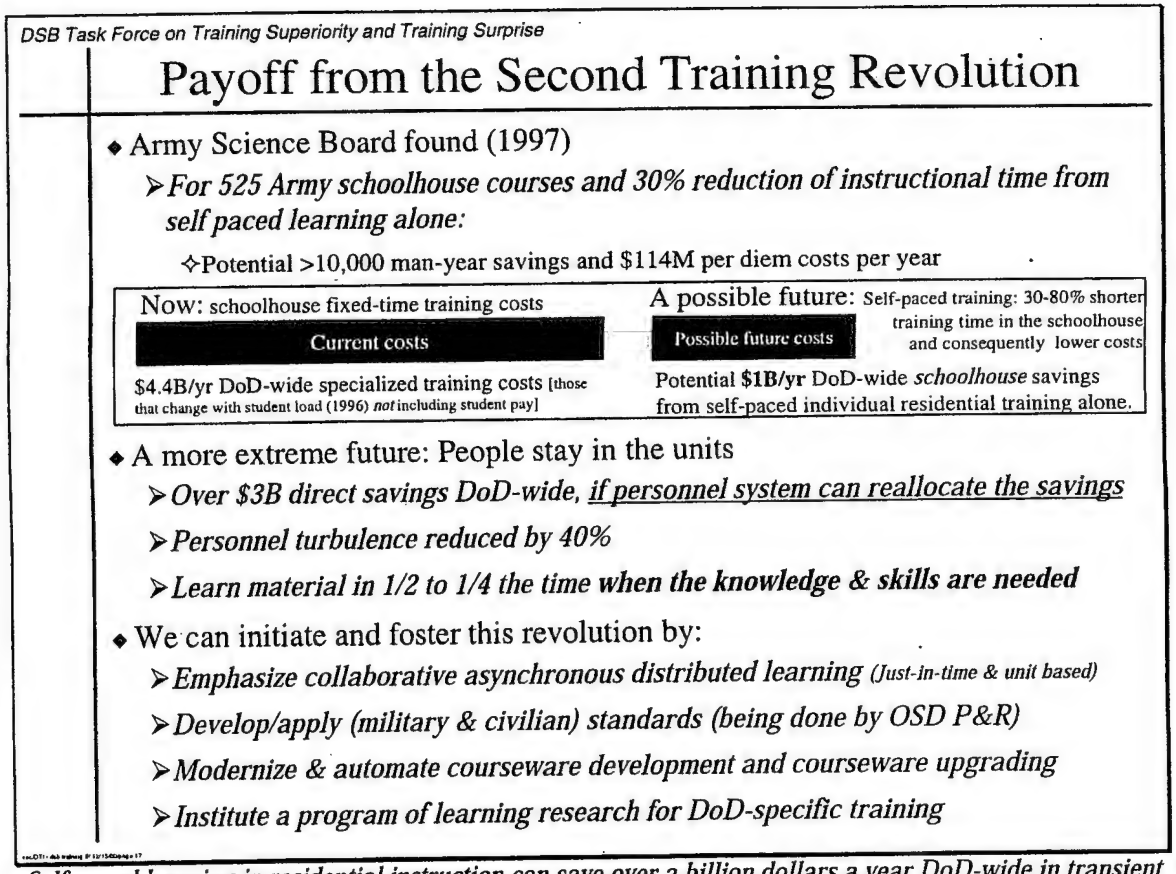
Individual performance on any one of these measures is relatively independent of performance on the other two. The military needs forces in which multiple kinds of capabilities are represented.

The Army could save $114 million in per diem costs alone simply from the reduction of instructional time in schoolhouses that would be delivered by the implementation of computer-based self-paced learning. These are not the only savings to be had, merely the easiest to count. We estimate that savings DoD-wide from reduced learning time in residential schools can easily amount to over a billion dollars per year; again merely from the introduction of self-paced training as opposed to classroom instruction. Indirect savings will be greater. These savings are "low hanging fruit". *They can be grasped,* however, *only if the money saved in the personnel system can be delivered to those who have to institute self-paced training in the schoolhouses.*

We see a second future with even more payoff, one that eliminates residential instruction for most technical courses and creates skilled Service members via distributed learning, self-paced courses, auto-tutors, electronic tech manuals, etc. With the people staying in their units instead of spending long times in the schoolhouse, this would help ameliorate the number one concern we heard from every field commanders we visited or heard from: personnel turbulence.

This won't come easily. The infrastructure to carry advanced learning out to the units must be paid for *in advance* by the training community before the savings accrue later in the personnel system. Moreover, many unit commanders will view this as shoving the burden of more training onto their unit, instead of as a way to keep people in the unit where they are available for contingencies. It is also a way to ensure that those people will have the needed skills well honed *while they in the unit* rather than be at their peak when they are in the schoolhouse. Nevertheless care must be taken when moving training into the unit to ensure that it does not simply add another task to the unit commander's already over-filled plate, and the concept must be carefully and compellingly sold to unit commanders.

If the structural problems can be overcome, the payoff from the second training revolution will free resources that will be needed to expand training efforts to support new forces such as the projected transformed army.



Self-paced learning in residential instruction can save over a billion dollars a year DoD-wide in transient personnel costs, if the personnel system can adjust to a variable course time. More savings and benefits could be delivered if people stay in their units.

When we made the case that effective training can change proficiency faster and more cheaply than the development of a new weapon system, we ran across the following argument. "When money is tight and the threat is low, the military should buy hardware, which endures longer than training, and hope to be able to take care of training later." This may, in fact, be a viable strategy to husband limited resources, but it should only be implemented after considering the consequences. It should not be done by default simply because training has little voice in the acquisition process. Unfortunately, the proficiency consequences that might arise from neglecting training are not measured today, nor could our task force find any existing tools that could be used to make such measurements.

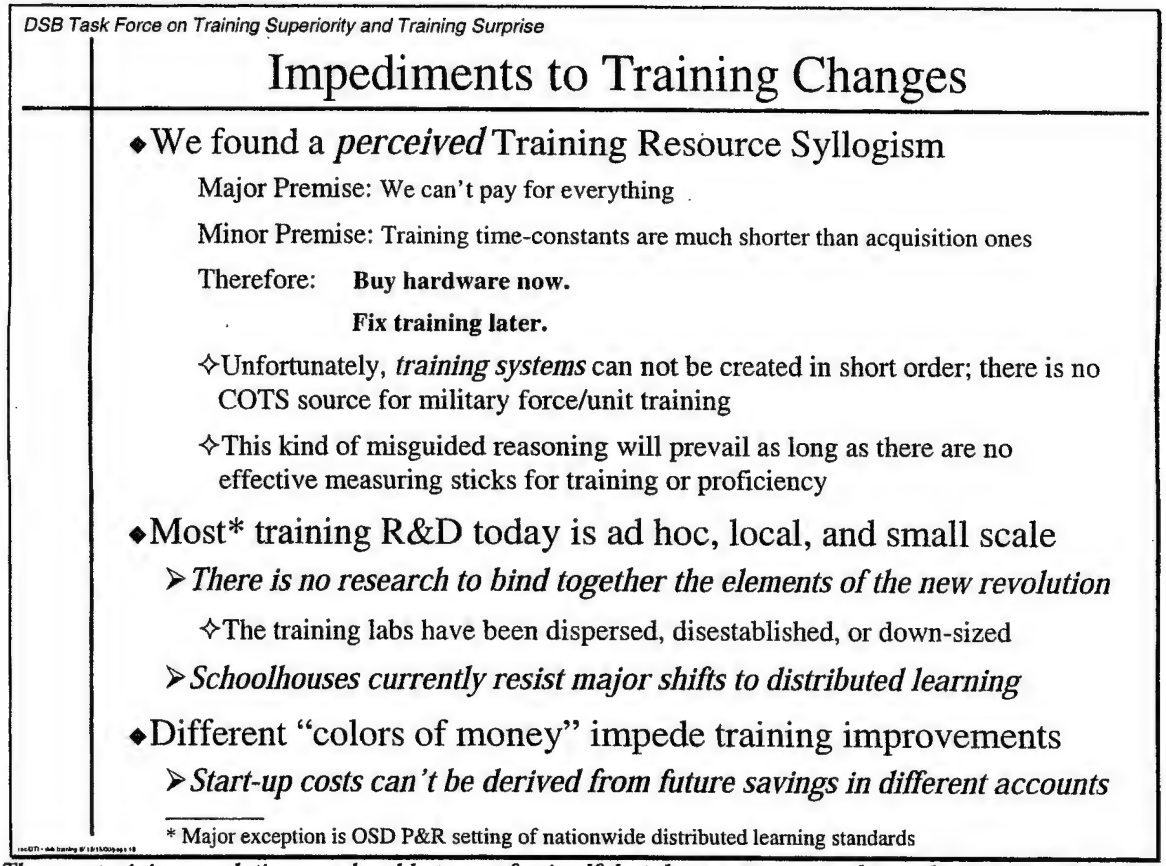
An additional factor militating against the "hardware now, training later" approach is that the kind of infrastructure that will deliver training to the point of need is itself hardware. There can be no commercial off-the-shelf source to train a brigade in land warfare nor a pilot how to fight his or her aircraft.

In the 1990s America's battles were come-as-you-are events allowing little or no time to rebuild a training system. We had time to send our ground forces through the National Training Center before they fought in Iraq, but we would not have had time to *build* the training center as well.

Our task force's job would have been made easier had there been a robust learning research community in the military, but there is none. We were shown by the Services training research managers mostly small projects with small budgets and small impacts, or we saw the tail end of formerly well-funded programs.

The acoustic training device, IMAT, was a notable exception. It, too, was a project with a small budget, but its impact was not small. Its success strongly suggests that there is great leverage for additional advanced research in training technology.

In the Office of the Secretary of Defense (OSD) there is a dynamic office of five people three layers down below the USD (Personnel and Readiness). They are the highest-ranking organization that even has the word "training" in their name. They have taken the lead in defining nation wide standards for distributed learning. Still, they are too small and too far down in the system to successfully remind the acquisition community that their weapon systems must have trained people to fight them effectively.



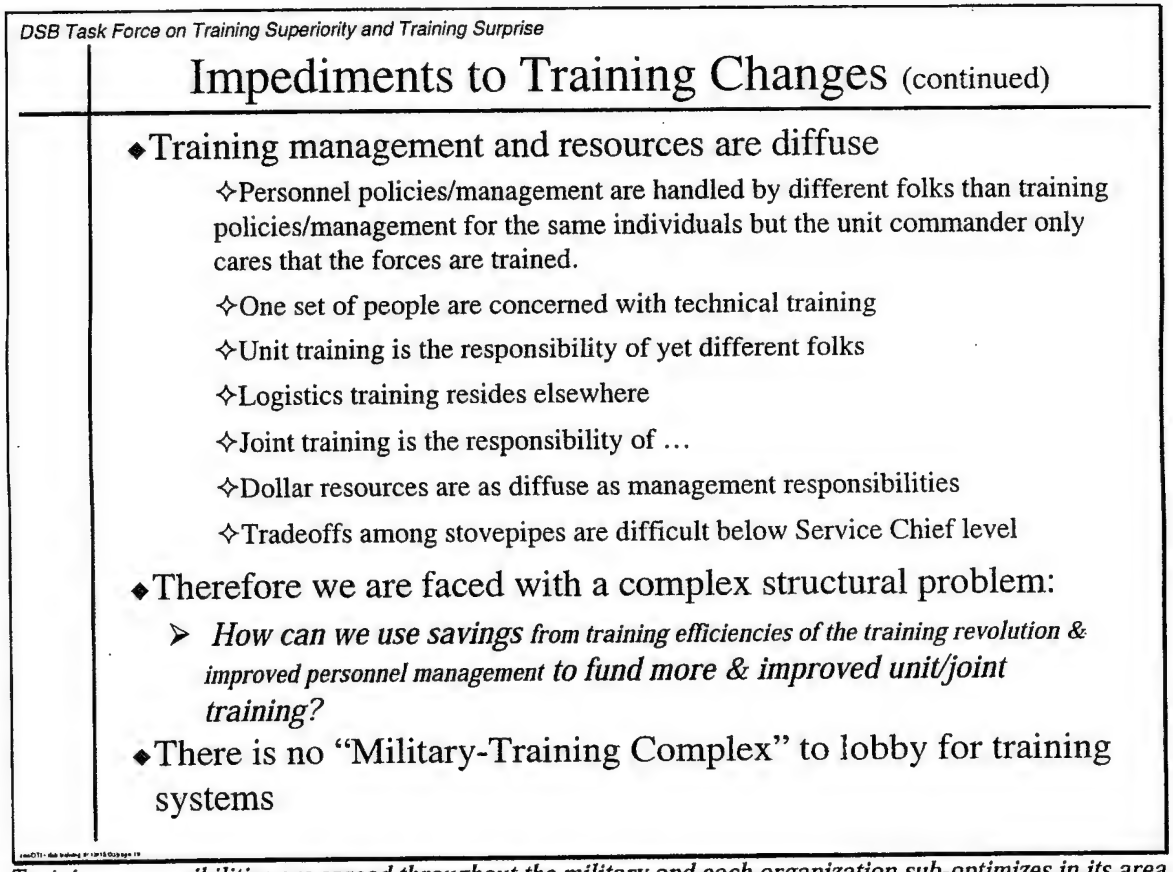
The new training revolution may be able to pay for itself, but there are structural impediments to making it do so. There is a general belief that training can be neglected when the funding crunch comes and there is no one with sufficient authority in the Pentagon to counter this view.

This task force was not established because a powerful defense organization saw a problem that desperately needed review. It was created in part because no organization *was* calling for training reforms. A large contributor to the problems we identified is the diffuse management of training. There are separate barons for individual training, for unit training, for training certain warfare system operators, for logistics training, and for joint training. There is logistics training and pilot training and submarine training, etc. Even in the individual training arena there is no consensus or leadership to identify or implement the types of changes that the training technology revolution will permit and will require.

We saw reason to believe that the DoD can maintain U.S. training superiority *and* make significant advances toward the next training revolution within roughly the same amounts of training resources currently used. It cannot be done, however, if the DoD continues to spend in the same way they have in the past. The personnel system and the training systems do not cooperate. The acquisition system is oblivious to both.

Effective training systems could generate personnel, acquisition, or operational savings. Conversely, expenditures during acquisition or in the personnel system can pay dividends in training savings, but there is no mechanism to make trade-offs among those administrative stovepipes.

When it comes time to distribute money in the Pentagon (or in Congress for that matter) there is no vocal constituency demanding funding for training. This makes it all the more important that structural changes be made to ensure that training issues receive sustained, continuing consideration throughout the DoD.



Training responsibilities are spread throughout the military and each organization sub-optimizes in its area, ignoring the trades that might save money elsewhere. For example, up-front design work to make a more useable/maintainable system might obviate a large training expense over the life of a system, but there is no incentive for an acquisition manager to pay for it.

Lord Kelvin is said to have stated, "If you can't measure something or describe it numerically, you have no right to discuss it." With respect to this aphorism our task force has been placed at a severe disadvantage. Neither training nor warfighting proficiency is well measured. Worse, the few attempts to make such measurements have perished.

For example, a 1982 DSB summer study on training recommended the establishment of a Training Performance Data Center. It took almost 4 years to get it started and it was eliminated a few years later in a territorial dispute with the personnel establishment. The importance of measuring training was not understood at a level high enough to protect it.

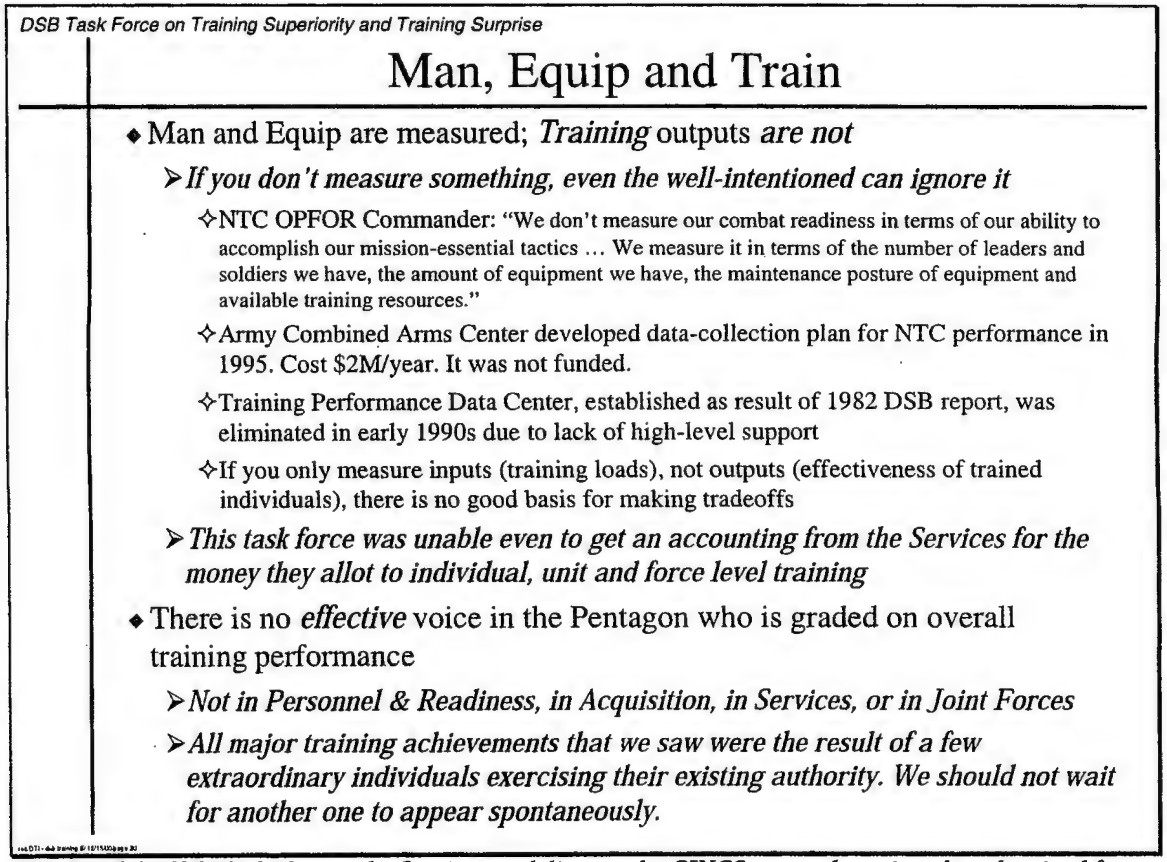
What *is* measured about training is throughput and process (e.g., the number of students and the number of classrooms, colloquially: butts in seats). What should be measured is whether the training delivered to individuals, to units, to commanders, and to joint task forces was efficient and effective: how the student or unit or task force performs after training.

Even for process measures, each Service defines training differently. Flight hours count as training for the Air Force. The Army has created a similar measure called "tank miles." The Navy considers ship time at sea as operations not training. Consequently, we could get nothing approaching a uniform accounting of training costs from the Services. One tried to provide such an accounting: a second Service tried when asked again; we gave up on the third Service after asking three times. No one is graded on training performance. No one is charged with assessing, and evaluating different parts of DoD training to see where marginal dollars should go to and/or come from in order to make the most productive improvements in force and unit capabilities.

The Services are charged in Title 10 to man, equip, and train the forces of our nation. There are well-established bureaucracies to oversee manning and equipping, but there is no comparable establishment that covers training in the sense described above.

Training development in the Services appears to be reactive rather than proactive. That is, the forces train to use what they are given, rather than choosing weapons characteristics based on whether people can be trained to operate them to good effect.

The first training revolution (and the IMAT acoustic trainer) was the result of the actions of a few individuals who did understand training in this sense. They were not the result of a training office exercising its charter (as is done for hardware) to identify, develop, and deploy training systems that would make changes to warfare proficiency. Training is seldom viewed in this light.



Title 10 of the U.S. Code directs the Services to deliver to the CINCS manned, equipped, and trained forces. Manpower and equipment are easy to count. Training is not. Without a numerical scorecard to tell how well we are training, even the well intentioned can ignore or miss training deficiencies.

Our task force did not feel it wise to sit back and hope that another extraordinary leader will appear to spearhead the next training revolution. Structural changes are called for in order that this kind of individual will have a better chance to be heard and be put in a position to insist, for example as General DePuy did 20+ years ago, that training become co-equal with the other major factors that build warfare proficiency.

We raised the following question. If the Navy could change its air-to-air exchange ratios by a factor of 6 in one year by the institution of new training techniques, is it possible for our potential enemies to do the same? In other words, should the U.S. be concerned about potential "training surprise" in the same way we have been watching for technological surprise.

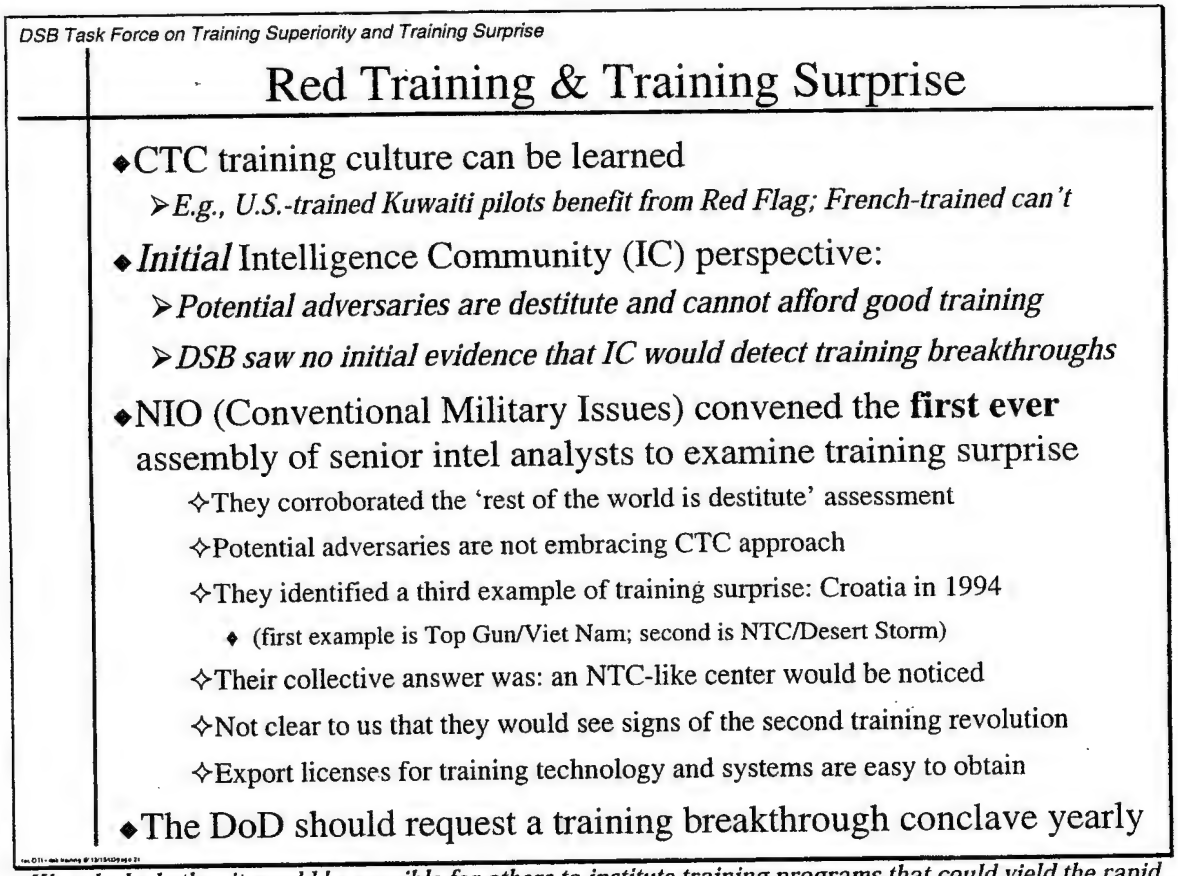
In pursuit of an answer we requested the Defense Intelligence Agency to describe the state of training of potential adversaries and whether they would recognize if one were instituting the equivalent of our CTC training. The answer we were given was that the rest of the world is too destitute to do training well. We were left with the impression that, like the acquisition community, they did not view training as something that could make order-of-magnitude performance changes.

We later raised the issue with the National Intelligence Officer for Conventional Military Issues, and he convened a group of senior intelligence analysts, explicitly tasking them to examine the issue of possible training breakthroughs. They corroborated the Defense Intelligence Agency (DIA) estimate that military training in most of our potential adversaries is poor.

They did point out that small groups of special forces in many countries are well trained and competent, even though the bulk of their forces are not. None of the special forces use the CTC approach to training, but by persistent and continual use of more conventional training they succeed in creating competent elite forces. North Korea's use of South Korea as a training ground for their commandos comes closest to the CTC paradigm, although, in this case, since the consequences of failure are more fatal than in a CTC, this comes closer to battlefield Darwinism.

The National Intelligence Office's (NIO) ad hoc group did, however, identify an additional instance of training surprise. (The U.S. experience with Top Gun and in Desert Storm are others, although the devastating consequences of those surprises were felt by our enemies, not by us.) This example occurred in the Croatian armed forces in 1993 and 1994. In the space of 1 year, with the help of a U.S. consulting firm, Military Professional Resources, Inc. (MPRI), with unusually strong political support from the top, and with adequate funding, the Croatians built a force that drove the Serbs out of their territory. They surprised not only their enemies but the rest of the world as well.

Croatia's success was the result of exceptional circumstances including not having an existing military to resist changes that made for effective training.



We asked whether it would be possible for others to institute training programs that could yield the rapid proficiency changes our CTCs give us. The answer is yes: it has been done, but widespread use is impeded by cultural issues. The intelligence community does <u>not</u> *, however, routinely look for such surprises.*

Successes such as this are likely to be rare.

The group assembled by the NIO *would* notice the implementation of a CTC-like training revolution in an adversary. We worry, however, that since they were assembled on a one-time basis, the focus raised by the NIO will fade with time. Nor were we convinced that the intelligence community would recognize the implications of what we have called in this report the second training revolution. We recommend that, as a minimum, the SECDEF should request a similar Training Surprise conclave annually to maintain the perspective in the IC that breakthroughs may be possible in training as well as in technology.

Recommendations

Recommendations

We had hoped to capture the essence of CTC training and recommend that it be bottled and exported electronically to other parts of the Services and to joint forces. We still so recommend, but find more urgent the restoration of the existing CTC infrastructure and its continual updating to meet the new threats.

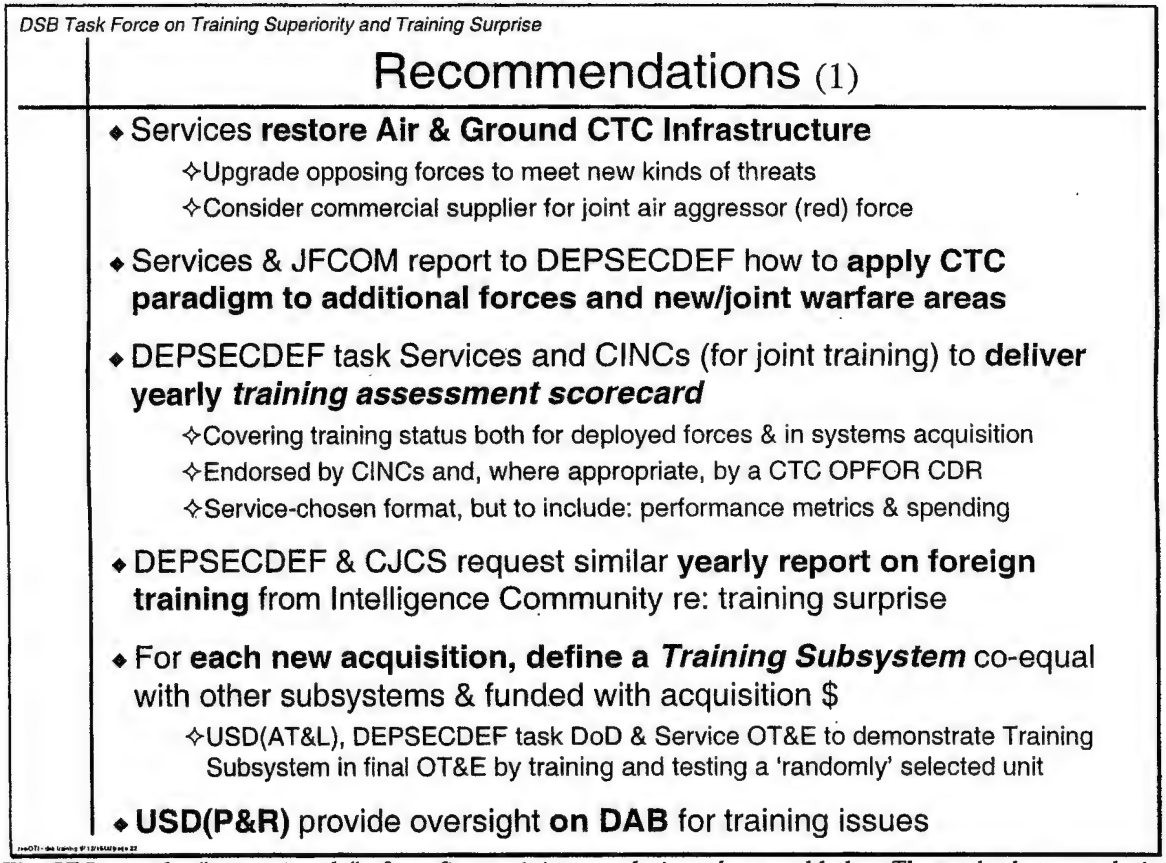
We believe (and were told by CTC operators) that air-to-air warfare training requires a robust force of "red" aircraft and pilots. Temporary-duty pilots in "similar" aircraft will not suffice. The Air Force has virtually no dedicated red air force and the Navy's will soon be worn out. We recommend that a joint force, possibly contractor supplied (aircraft & pilots), be created and adequately funded.

This will not be enough. The primary threat in America's recent air battles has been from integrated air defenses composed mostly of ground-based systems. The air CTCs no longer have threat-representative "red" systems. A top Service priority should be to keep all CTCs' red forces current.

In acquisition we recommend that each development program be required to designate a "training subsystem" charged with creating the infrastructure to ensure that the hardware will have trained operators and maintainers throughout the life of the system. This training subsystem should be funded with acquisition dollars and its development should have equal priority with any other vital subsystem. The proficiency delivered by training and its long and short term costs should be traded against hardware performance.

The training subsystem must be tested as well. We suggest that the operational test and evaluation (OT&E) process determine whether the training approaches developed by the acquisition program will work. One way is to take a unit that has done no special OT&E work-up, subject it to the training system, and evaluate its performance using the tested weapon. This approach should prevent situations like the first submarine with ARCI modifications reporting "not ready for sea" due to a failure to consider training during the development. It should also detect before-hand situations such as the one in which for 10 years a missile system was used at less than half its potential range because of failure to provide for training during acquisition. USD (Personnel and Readiness) should sit on the Defense Acquisition Board to ensure that these issues are addressed.

Our final recommendations relate to raising training consciousness throughout the military. Training performance needs to be reviewed at the highest levels.



The CTCs are the "crown jewels" of our first training revolution; they need help. The trades between design and future training can be made if a training subsystem is integral to acquisition programs. Training deficiencies will be harder to ignore if a formal report is delivered yearly.

The Pentagon decision-makers need to be reminded often of the leverage that training can have in winning wars. The Services should be held accountable for the third leg of their Title 10 charge. Joint training should be reported upon by the CINCS who are charged with this function. The format of the annual report is not important. What is important is that in the process of generating it, the Services will be forced to develop measures of *training effectiveness.* We would hope that in the process, the measurement of training success would migrate up through the units and into joint forces and that, with such measures available, people would be held accountable in new ways for training *performance.*

In a similar way the Intelligence Community should report at a very high level in the DoD on the state of training in the rest of the world with emphasis on all forms of training breakthroughs.

The impending training revolution will take current knowledge of learning behavior and apply to it the electronic revolution in order to deliver the right skills at the right time and place. It will not be enough to simply let electronic technology proponents lead with new and amazing gadgets; an understanding of how people learn is vital. Computer technologists believe, as do most of us, that they know what is needed to teach skills. Unfortunately, much of what we know is wrong. Both learning theory and technology are required. This motivates our recommendation that the Defense Advanced Research Projects Agency create a new office and institute a research program in high-payoff training technologies.

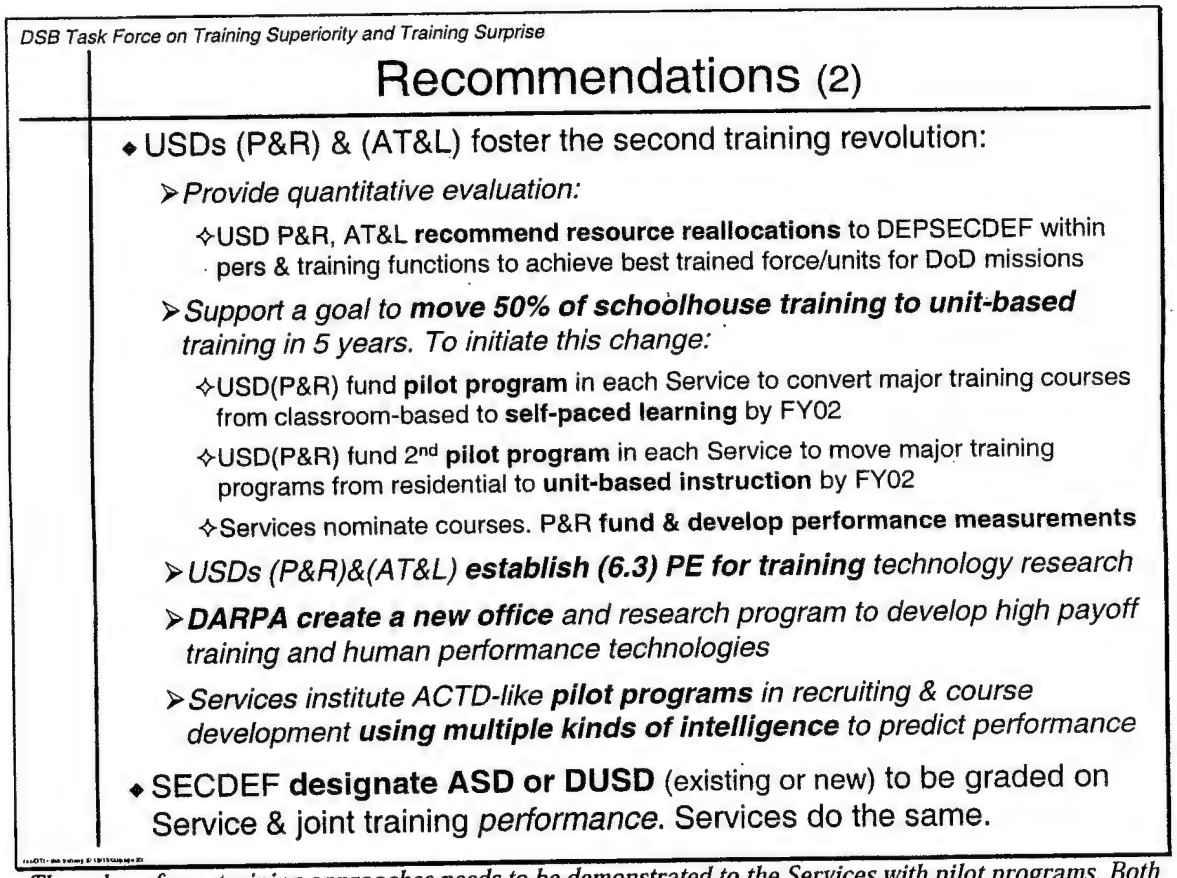
Fomenting the next training revolution will require that the DoD think about training in a new way: not reactive but proactive. Implementation of the first recommendation in the viewgraph would force the personnel and acquisition establishments (man and equip) to consider how to trade off hardware against training costs to deliver the most effective force.

We recommend a goal of moving 50 percent of residential instruction out to the units in 5 years as well as converting most of the remaining schoolhouse training to computer-based, self-paced, collaborative courses. To get this started we recommend the creation of several Advanced Concept Technology Demonstration (ACTD)-like prototype programs. Perhaps they should be called Advanced Concept Training Demonstrations, although they would have a substantial technological content.

An ACTD joins together reasonably well understood concepts into a pilot demonstration that has clear use to the military. It does not end with the demonstration, but leaves behind a residual capability that is supported for several more years. This gives the Service time to adopt the capability if desired. Once initiated, an ACTD should have stable funding throughout its life. Pilot programs created under this recommendation should have similar structural characteristics.

We recommend a second class of ACTD-like pilot programs to demonstrate the value of the concept of several kinds of intelligence. This should improve the coupling of training to the individual and allow better predictions of success in the Services, thus widening the pool of applicants. Each Service should explore this approach, possibly with the aid of DARPA.

Although not discussed elsewhere herein, we became concerned that the issue of interoperability within and among the Services

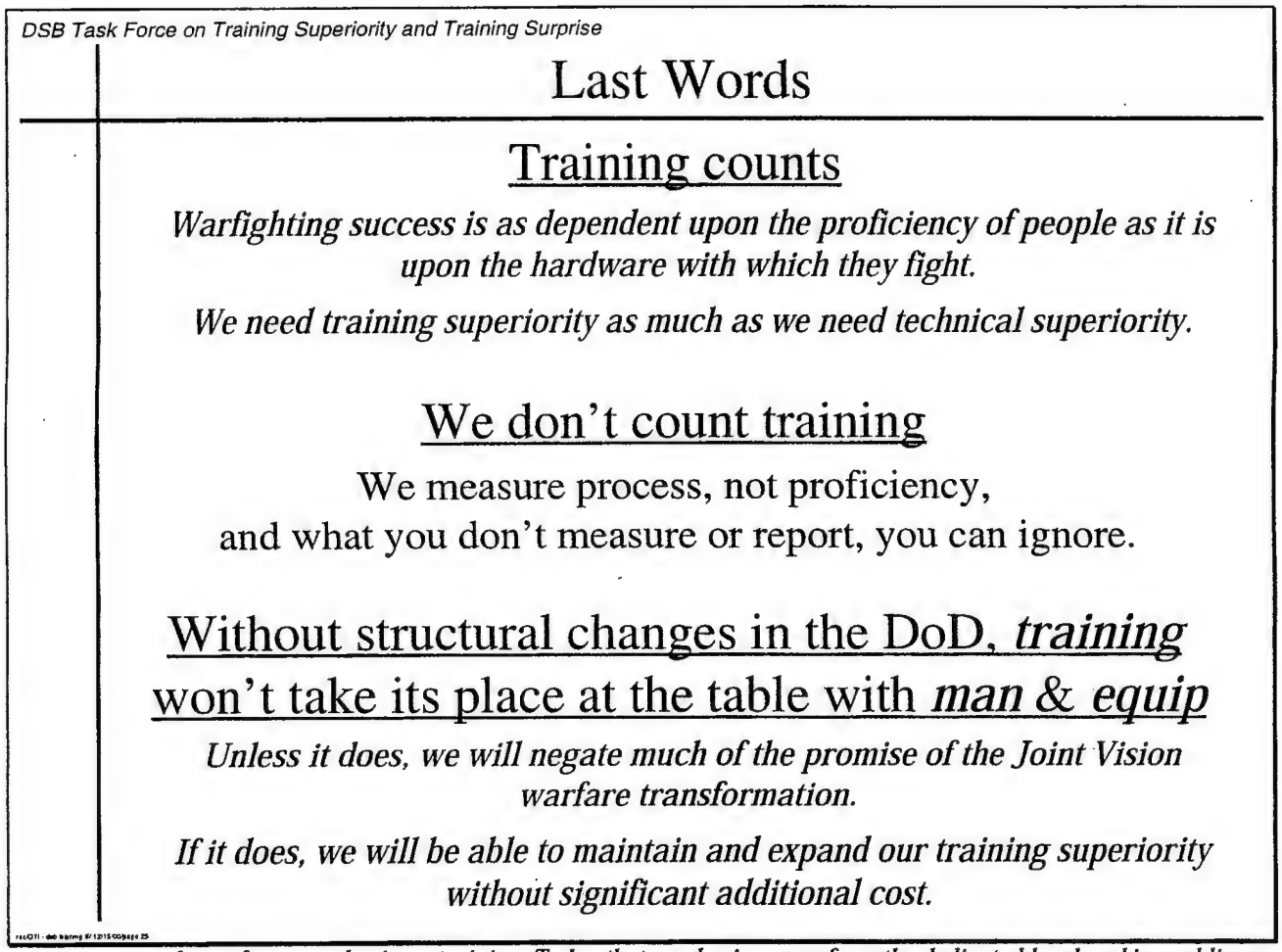


The value of new training approaches needs to be demonstrated to the Services with pilot programs. Both training effectiveness and retention can be enhanced by testing for more than analytic intelligence. Somebody needs to be in charge; a standard DSB recommendation, perhaps, but nevertheless valid.

may become a downfall of future warfare. Innocent changes in one system can have a cascading effect on performance of the whole. This deserves a separate DSB review.

Finally, there is the question of who is in charge. We have been told that the universal DSB recommendation to all problems is: put someone in charge and give him or her money. Our task force endorses this principle, cliched though it may be. Training of the kinds discussed in this report will not flourish in the current administrative structure; it will remain reactive unless there is a champion. The champion could be the head of a new office or the recipient of a new tasking to an existing office.

Conclusion



There is no military-training complex to force emphasis on training. Today that emphasis comes from the dedicated hardworking soldiers, sailors, airmen, and marines in the field. Our key recommendations relate to making training visible at higher levels. If we are to restore the first training revolution's institutions, if we are to upgrade them to meet the current threat, if we are to expand them to support JV2010/2020 warfare, and if we are to foster a second training revolution, the DoD must change.

This is the last chart. If, after all of the foregoing text, this chart doesn't stand by itself, there is nothing here we can do to fix that.

This viewgraph is the same one you saw at the beginning, but the accompanying words are different.

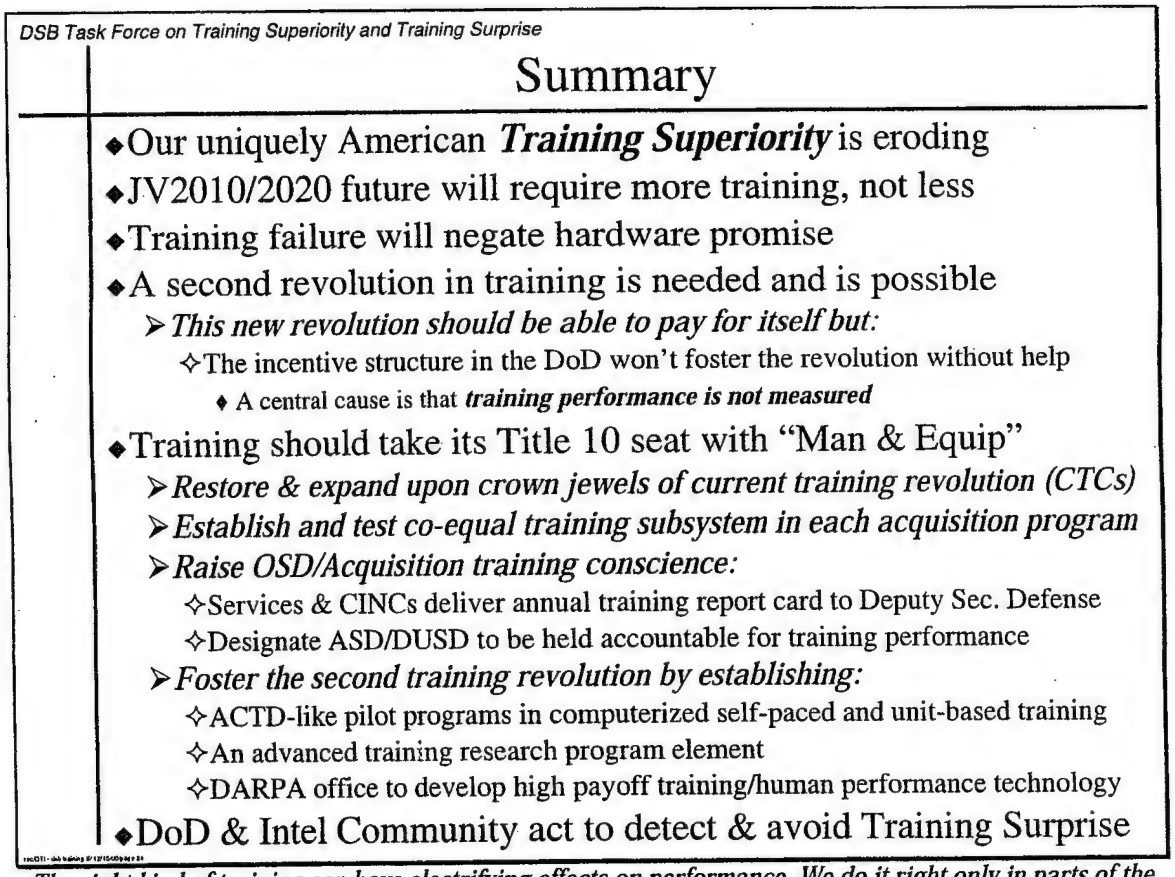
Our task force's principle finding is that the United States military enjoys a huge training superiority over our potential adversaries. This second superiority is at least as important to warfare performance as is America's better advertised technological superiority. We should not rely on technological superiority alone. It could not bring victory in Viet Nam, nor is technology alone likely to be sufficient for future victories. Since Viet Nam, actions by a few foresightful individuals caused our air forces and Army ground forces to adopt a new form of warfare training that has created a training competence complementary to our technological competence and, in part, supported by it.

We cannot rest on our laurels. We would need to reduce the cost of training even if nothing in warfare were to change. Warfare will change and training must change with it or we will be unable to fight our future combat systems, our JV-2010/2020 forces, or even maintain logistics systems that sustain our new agile and flexible forces.

Without a second revolution in training affairs, the revolution in military affairs will not be supportable. That new training revolution is ripe for the picking; there is an emerging quantitative understanding of how to develop effective training approaches, and the electronic revolution now makes affordable their widespread application. These factors include individualized instruction, direct feedback on performance, beating the forgetting curve by delivering training at the time and point of need, and collaborative and self-paced learning.

However, unless we make structural changes to the DoD, the newest training revolution won't succeed until long after it is needed. If we fail to make those changes, training will remain an afterthought, something slapped together ad hoc to address failures like those that occurred in the I-HAWK or ARCI programs. Such failures will be paid for by the Service members we send into harm's way and will waste much of the hard-won resources spent on acquisition of new (and old) weapon systems.

The structural changes we recommend hinge upon making training issues routinely visible to those who write checks in the Pentagon. There is no COTS source for advanced military training nor is there a large industrial lobby to remind decision-makers about the importance of training. This lack of external reminders makes structural change all the more important both to preserve our training superiority and to prevent training surprise from our adversaries.



The right kind of training can have electrifying effects on performance. We do it right only in parts of the Services and even that capability is eroding. We must do more if we want to fight the new Joint Vision kind of warfare. We won't get there on the present course. Worse, there is no single hand at the helm.

The key recommendation for fixing the present is to devote more resources to the crown jewels of the U.S.'s first training revolution, the CTCs, to permit JV2020 kinds of training against new threats. The key to fixing the future is high-level training report cards. It doesn't matter in what format the Services or the intelligence community tells the SECDEF about the state of training, what matters is that the reports are delivered. The attention arising from these reports should aid implementation of our other recommendations and sustain recognition of the extraordinary value of training to winning wars.

Appendix A

Terms of Reference

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

FEB 2 2 1999

ACQUISITION AND TECHNOLOGY

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference—Defense Science Board Task Force on Military Training and Education.

You are requested to conduct a task force to analyze the impact of training techniques and the potential future learning environment upon the warfare proficiency of our military forces, active and reserve components, and that of potential adversaries in the context of Joint Vision 2010 warfare.

The performance of military systems is frequently more dependent upon the people who use them than on the technology embedded within them. Therefore, the way we train our forces and personnel may have as great an influence (good or bad) over mission performance as our choices of hardware. Done right, training may be the most cost-effective method to maintain force proficiency and the most rapid method to enhance it. Neglect of training can, however, be the fastest way to negate the benefits of our military technology and force structure.

For the past 30 years elements of the U.S. armed forces have implemented training techniques that demonstrably improve unit warfare proficiency many-fold in time frames as short as a few weeks. Equal investments in other kinds of unit training frequently yield only marginal benefits. We can not afford to waste our hardware or training expenditures by failing to train well the individuals and units who will operate our future weapons systems. Moreover, there now appears to be the potential to go beyond the best training approaches of the past by bringing information resources and networks into an ensemble of education, training, and performance aiding systems. If these can be embedded into operational weapon systems and job environments, they may profoundly change the way we do business in the military.

Costs and benefits of training and education should be debated on the same footing as other DoD programs that are intended to maintain and improve military capability. Your task force should not just recommend training and educational techniques and technologies for the DoD; it should also show how to make these benefits and their costs routinely visible throughout the DoD.

Specifically the task force should consider the following areas.

1) UNIT/FORCE-LEVEL PROFICIENCY: The task force should identify key training demands that affect development and maintenance of military proficiency.
2) INDIVIDUAL WARRIOR/HUMAN COMPETENCE: Underlying the ability to maintain military *units* that will be proficient in future missions is the availability of technically and militarily competent *individuals*. The task force should recommend how to create and maintain individual proficiency among our warriors and support personnel.
3) MILITARY TRAINING INFRASTRUCTURE: The task force should identify key areas where DoD-wide processes and methodologies, such as advanced distributed learning,

embedded training, global networks and information resources, netted training, advanced simulations, and weapons system stimulators, may be needed. It should identify opportunities to enhance or maintain capabilities with reduced or minimal added costs.

4) MONITORING TRAINING vs. PROFICIENCY IN POTENTIAL ADVERSARIES: The leverage arising from training technologies and approaches might also be used by potential adversaries to improve their military proficiency, rapidly and with low costs. The task force should identify useful indicators of high-leverage training programs for use by the intelligence community to prevent training surprise.

In the pursuit of your study, the task force should:

a) Assess the Current State of Training in the DoD to evaluate what we do well, what we need to do better, and the requirements for future training. Consider also how potential adversaries pursue training.

b) Identify Technical Opportunities. What are the characteristics and advantages of possible future learning environments, and what are the key enablers to achieving those environments?

c) Explore Private-Sector Partnerships. Determine if there are opportunities in training equivalent to commercial-off-the-shelf hardware acquisition.

d) Identify Opportunities for improving the process for training of our warfighting, maintenance, and support personnel.

e) Assess the payoffs, costs and benefits (including how implementation may change the way we operate our forces.) Consider the opportunities for, and impediments to implementing each alternative (the mismatches among bureaucracies, budget lines, cultures, and technologies). Identify training/performance metrics that can be routinely raised to the attention of decision-makers and trainers throughout the Defense Department.

f) Recommend Policies, Plans, and Programs. Identify what actions (organizational, budgetary, etc.) will be necessary, to enable the development and implementation of advances in individual, collective, and unit training, by OSD and the Services. Identify also how we can avoid being surprised if a potential adversary were to implement these actions in its own forces.

This Task Force will be co-sponsored by the Undersecretary of Defense (P&R), Director DDR&E, and the Joint Chiefs of Staff (J-7). Mr Joe Braddock and Dr. Ralph E. Chatham will serve as the Task Force Co-Chairmen. Michael A. Parmentier from OUSD (P&R), will serve as Executive Secretary and Captain Jim Lyons, USN, will serve as the Defense Science Board Secretariat representative.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

J. S. Gansler

Appendix B

Acronyms Used

ACTD	Advanced Concept Technology Demonstration
AFB	Air Force Base
AFHRL	Air Force Human Resource Lab
ARCI	Acoustic Rapid COTS Insertion
ASD	Assistant Secretary of Defense
CINC	Commander in Chief
CJCS	Chairman Joint Chiefs of Staff
COTS	Commercial Off The Shelf
CTCs	Combat Training Centers
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Project Agency
dB	Decibels
DEPSECDEF	Deputy Secretary of Defense
DIA	Defense Intelligence Agency
DMT	Distributed Mission Training
DoD	Department of Defense
DSB	Defense Science Board
DUSD	Deputy Under Secretary of Defense
EW	Electronic Warfare
GM	General Motors
GRE	Graduate Record Examination
IADS	Integrated Air Defenses
IC	Intelligence Community
IETMs	Integrated Electronic Technical Manuals

IMAT	Interactive Multi-Sensor Analysis Trainer
IOC	Initial Operational Capability
JFCOM	Joint Forces Command
JTASC	Joint Training, Analysis, and Simulation Center
JV 2010	Joint Vision 2010
JV 2020	Joint Vision 2020
MPRI	Military Professional Resource, Inc.
NAS	Naval Air Station
NIO	National Intelligence Office
NSF	National Science Foundation
NTC	National Training Center
OPFOR	Opposing Force
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
R&D	Research and Development
RMA	Revolution in Military Affairs
SECDEF	Secretary of Defense
TOW	Tubular Optical Weapon
USA	United States Army
USAF	United States Air Force
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USD (P&R)	Under Secretary of Defense for Personnel and Readiness
USN	United States Navy